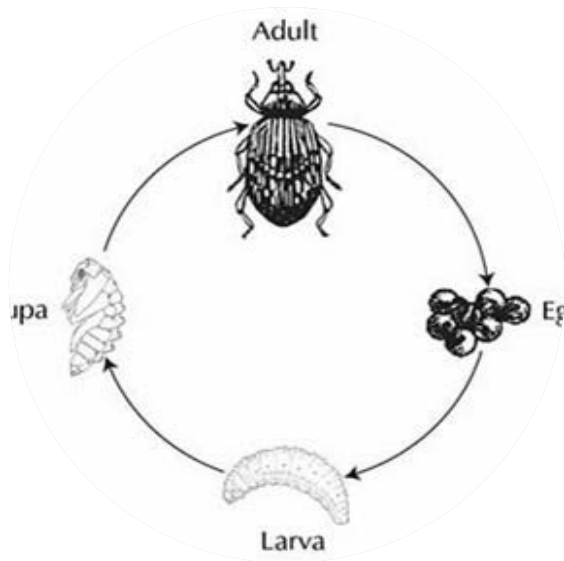


Growing Insect culture in Europe as protein in fish feed: risk of pathogen transfer

Olga Haenen*, A. Borghuis, G. van Duijvendijk, E. Weerman, B. Schoelitz, L. Bonte, L. Dingboom, H.J. Roest, P. de Cocq

**Head of NRL for Fish Shellfish and Crustacean Diseases; Professor INVIS at HAS University of Applied Sciences*



Background: insects for **feed** and **food**?

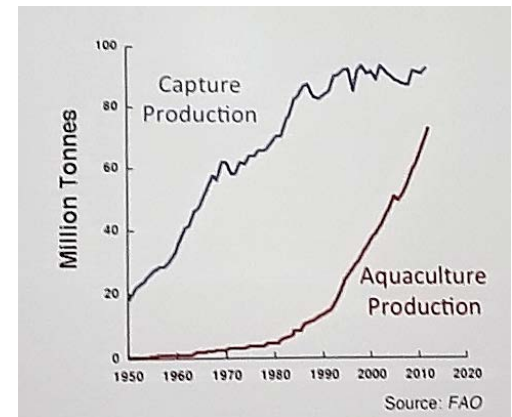
We need to find alternative protein sources to be able to feed the world (various FAO reports)

Aquaculture production and fish meal prices: increasing

Put **insect meal** in **fish feed** instead of **fish meal**, also more sustainable?

And for **humans**:

- Insect fed fish as **food**
- Insects as **food**



→ **INSECT FARMING STARTED** decennia ago:

Easy, fast, efficient, low in rules

Background: sustainable protein production

- **Commercial insect branch**, since 2007, **NL + BE**, 2015:
 - **Mealworms** *Tenebrio molitor*: >2500 tons/yr of larvae (7 farms)
 - **Lesser Mealworm**, *Alphitobius laevigatus*: >150 tons/yr (4 farms), a.o.
 - **fly** larvae culture at GFT side streams
 - **Black Soldier Fly** 
 - **cricket**, etc. 
 - 25 farms in NL, 500 tons/yr



Source: dendroshop.de



Some cultured Insect species

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Lesser Meal Worm

Alphitobius diaperinus

0,7 cm



Meal Worm

Tenebrio molitor

1-2 cm



Giant Meal Worm

Zophobas morio

2,5-3cm



Industrial insect culture worldwide

(from: Prof. van Huis, WU, Ede, NL, 21st March 2018)

Black Soldier Fly culture, China



Entomo Farms, Cricket farm, Canada



Protifarm, the Netherlands (lesser meal worm)



Some farms are expanding 10-fold

...a booming industry!

Microbial biosecurity often not in focus

FAO, WUR, and edible insects culture:

meeting, Rome, 2012 -->

book: <http://www.fao.org/docrep/018/i3253e/i3253e.pdf>



And: FAO Conference 'Insects to feed the World' in Ede, NL (May 2014) ➔ urgent need for diagnostic lab for edible insects in NL and BE, a.o. countries (disease and contaminants)

And: Oct 2015: Federation of Veterinarians in Europe (FVE) day, Nieuwegein, NL: Insects, food for thought and vets! Pet food branch was present, a.o.

And: WUR Conference "Edible insects : the value chain", Ede, NL, 21-22 March 2018: Biosecurity of edible insect culture urgently needs more attention

Insects in fish feed? Pilot project with **Black Soldier Fly (BSF) meal in salmon** : *Protix* (NL) and Uni

Bergen (N) a.o. (E.-J. Lock et al., 2015 and 2018)

'AquaFly' (NRC) project- Insects as sustainable feed ingredients for Atlantic salmon

Insect meal:

- <50% **fish**meal replaceable by **BSF** meal without problems
 - Odour, flavour/taste, texture of the salmon the same
 - Favourable AA profile compared to f.i. with soy meal
 - Highly digestible lipid
- **promising!** Some BSF farms expand 10-fold!

News pages on insect meal for salmon, Feb 2018

(courtesy E.-J. Lock, Ede, March 2018)

First crop of insect-fed salmon shows promise

News by William Stoichevski 13 February 2018

Norwegian fish-nutrition researchers taking part in Europe-wide studies to produce aquafeed from insect protein confirm they have the first "harvest" of 1,200 Atlantic salmon raised on the black soldier fly's protein.

First salmon raised on insect-based proteins

By Undercurrent2 News Feb 12, 2018 10:01 GMT



PUBLISHED ON MAR 7, 2018

Facebook, Twitter, LinkedIn, YouTube, RSS icons



Why Salmon Eating Insects Instead of Fish Is Better for Environment

Companies in Europe have developed new kinds of feed for salmon farms that could help the environment—if they can scale up quickly.

Facebook, Twitter, LinkedIn, YouTube, RSS icons



EXI



For FOOD: INSECT PRODUCTS

©Proti-Farm Holding BV, acknowledged



HYBRID MEAT PRODUCTS



For **FOOD**: Insects as sustainable new protein source, innovative, trendy

LIFE

Ikea test kitchen's new menu has Swedish meatballs made out of mealworms

Ali Montag | @Ali_Montag | 9:44 AM ET Fri, 16 March 2018



For Food, but first also for Feed: Analysis: the chain: Risks of pathogen transfer?



RISKS



- Substrate contaminated? (pathogens a.o.):
- Insect farmer at risk regarding potential zoonotic pathogens?
- Insects at risk regarding veterinary pathogens?
- Fish at risk regarding insect meal with contaminants/potential pathogens?
- Humans at risk for regarding food safety through consumption of insects and fish?

Fish and insect should become part of a healthy, sustainable and safe chain, from culture up to final product for the consumer

EU legislation on edible insects: a selection regarding aquaculture



- 999/**2001**/EC regulation: **proteins** may be extracted from e-insects for aquaculture animals
- 1069/**2009**/EC (art.35) regulation: insects produced on vegetal, dairy and egg may be fed directly to **pet** animals. Farms should be authorized and registered by Vet Auth., also as slaughter house (regarding TSE risk)
- 142/**2011**/EC (**substrate** for insect culture may only be **vegetal, egg, or dairy** based) because of TSE risk
- 893/**2017**/EC (allowing **insect meal in aquaculture feed**)
- Regulation on use of insect meal in **chicken feed** is drafted

This will further boost the edible insect industry...

HAS University of Applied Sciences, Den Bosch, NL: new lectorship



- <https://www.hasuniversity.nl/about-has>
- HAS University of Applied Sciences is the best educational and expertise Centre in the Southern Netherlands for the agrifood and environment sectors, with 2 sites

English-taught

OUR BACHELOR PROGRAMMES

**BUSINESS MANAGEMENT
IN AGRICULTURE & FOOD**

Venlo

**HORTICULTURE &
BUSINESS MANAGEMENT**

Den Bosch

**INTERNATIONAL FOOD
AGRIBUSINESS** CHALLENGE

Den Bosch



UNIVERSITY & RESEARCH

The lectorship *INVIS*



our flyer

From crustacean
disease to insect disease...

Cooperation of HAS with
WBVR with the industry of
Insect culture, fish culture
and feed mills

NOVEL PROTEINS: INSECTS AND FISH, HEALTHY, SUSTAINABLE AND SAFE (*INVIS*: A NEW LECTURESHIP)

O. Haenen^{1,2}, **A. Borghuis**¹, **G. van Duijvendijk**¹, **E. Weerman**¹, **B. Schoelitz**¹,
L. Bonte¹, **L. Dingboom**¹, **H.J. Roest**², **P. de Cocq**¹

Introduction

A New lectureship at HAS University of Applied Sciences 2018-2022: In close cooperation with the Fish and Crustacean disease laboratory and epidemiologists of Wageningen Bioveterinary Research at Lelystad (WBVR).

Aims:

Extend and integrate knowledge, experience, and education on healthy and safe insect and fish culture: Investigate risk factors and support the use of healthy and safe insects in aquaculture feed in cooperation with feed processors.

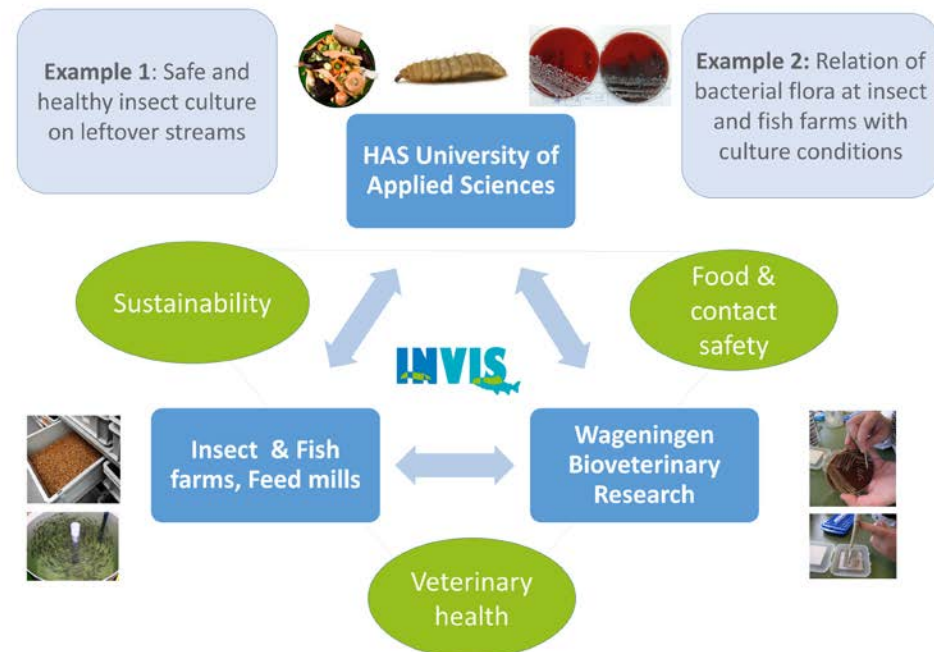


Figure 1. The INVIS lectureship at HAS University of Applied Sciences, Den Bosch. The main themes and interactions, and synergy between partners are given.

Other partners are welcome.

¹HAS University of Applied Sciences, Dept. Applied Biology, P.O. Box 90108, 5200 MA 's-Hertogenbosch, the Netherlands
²Wageningen Bioveterinary Research, NRL for Fish, Shellfish and Crustacean Diseases, P.O. Box 65, 8200 AB Lelystad, the Netherlands

INVIS : aims:



Extend and integrate knowledge, experience, and education on **healthy and safe** insect and fish culture

Select and research leftover streams as basis for **healthy, sustainable, and safe** insect production

Investigate **risk factors** and support the use of healthy and safe insects in aquaculture feed in cooperation with feed processors, to start with aquaculture feed

Substrate: Organic waste and Swill



Organic waste (OW)

Swill



Potential pathogens present?

Risk for the insect?

Risk for the insect farmer?

Risk for fish via feed?

HAS University of Applied Sciences, Den Bosch



Lab Bacteriology and mycology



Insect Lab *Applied Biology*

Pilot substrate with mealworms:
Bacterial and yeast growth
after 2 d at 28°C (Haenen *et al.*)

Which species?

Analysis: Which problems in Insect culture (as basis for disease and mortality)?

- **Unexplained, sudden high mortalities**
- Disease in various species
 - many fungi
 - viruses
 - bacteria
 - parasites
- **Mostly: Management-related problems...**
- **Important: diagnostic lab **KU Copenhagen**, Denmark.... Prof.dr. Eilenberg *et al.***

Diseases in insects produced for food and feed



Eilenberg et al., 2015

Diseases in insects produced for food and feed

J. Eilenberg^{1*}, J.M. Vlak², C. Nielsen-LeRoux³, S. Cappellozza⁴ and A.B. Jensen¹

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REVIEW ARTICLE

Abstract

Increased production of insects on a large scale for food and feed will likely lead to many novel challenges, including

Mealworm *Tenebrio molitor*: nematode infection by *Steinernema feltiae*

(picture: Courtesy Erin Morris, in Eilenberg *et al.*, 2015)



healthy

infected



Fungi (often secondary)

Larve of mealworm infected with *Beauveria bassiana*

(picture: Courtesy Erin Morris, in Eilenberg *et al.*, 2015)



House fly (*Musca domestica*) killed by *Entomophthora muscae sensu lato*

(picture: Courtesy Henrik de Fine Licht, in Eilenberg et al., 2015)



Some detected fungi of insects

yes/no pathogenic?

- *Metarhizium* sp.
- *Cordyceps* (former name *Beauveria*) *bassiana*
- *Aspergillus* sp.
- *Cladosporium* sp.
- *Fusarium* sp.
- *Trichothecium* sp.
- *Ascospaera*
- *Entomophthoromycota*
- *Hypocrealis*, etc.

Larva of mealworm infected with unknown bacteria, may even be postmortal

(picture: Courtesy Erin Morris, in Eilenberg *et al.*, 2015)



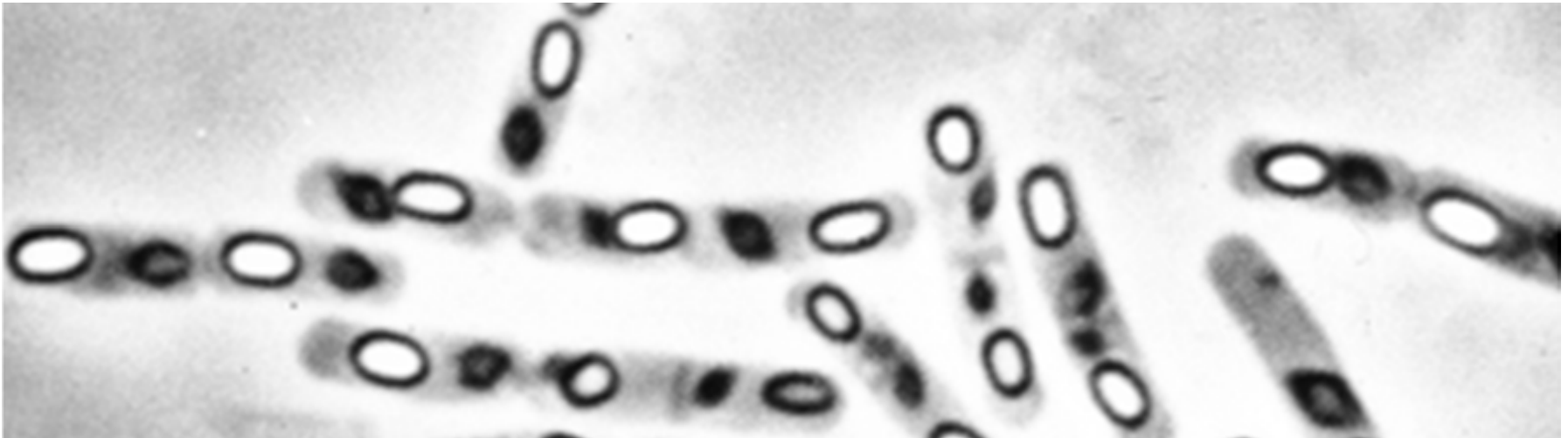
Silk worm *Bombyx mori* larvae (5th instar) with *Enterococcus mundtii* infection

(pictures: Courtesy Silvia Cappellozza in Eilenberg et al., 2015)



Bacillus thuringiensis, microscopic 2-3 μm long, with spores and **toxin crystals**

(picture: Courtesy Christina Nielsen-Leroux, in Eilenberg et al., 2015)



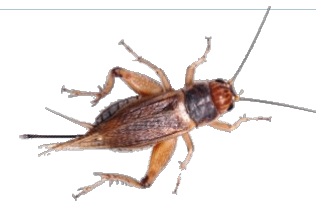
Literature search, scarce on **insect diseases** (other than from viruses): **some bacteria**: pathogenic?

- *Aeromonas* spp.
- *Serratia liquefaciens*
- *Serratia marcescens*
- *Acinetobacter baumannii*
- *Lactobacillus antri*
- *Lactococcus formosensis*
- *Staphylococcus arlettae*
- *Buttiauxella agrestis*
- *Pseudomonas aeruginosa*
- ***Rickettsiella* spp.**

Klebsiella, Enterococcus, Providencia, Alcaligenes, Cirrobacter, Pseudomonas, Bacillus Sphingobacterium, Morganella, Ochrobactrum, Acinetobacter, Paenalcaligenes, Miniimonas, Paenochrobactrum, Cronobacter, Verrucomicrobia

*Pseudomonas aeruginosa
Bacillus thuringiensis
Bacillus amyloliquefaciens
Bacillus cereus
Bacillus laterosporus
Bacillus licheniformis
Bacillus megaterium
Bacillus pumilus
Bacillus subtilis*

VIRAL INFECTIONS of crickets



(Eilenberg et al., 2017 in book Van Huis & Tomberlin, 2017)

Naam	Virus-familie	Host species
AdDV <i>Acheta domestica densovirus</i> (since 1977 in France, furthermore USA, Canada, Japan)	parvo (DNA)	<i>A.domesticus</i> , <i>Gryllodus sigillatus</i> , <i>G.locorojo</i>
CrIV cricket iridovirus	irido (DNA)	<i>A.domesticus</i> , <i>Gryllus campestris</i> , <i>G. bimaculatus</i> , <i>G. assimilis</i> , <i>G. texensis</i>
CrPV Cricket paralysis virus	dicistro (RNA)	<i>Teleogryllus oceanicus</i> , <i>T. commodus</i> , <i>A.domesticus</i>
GbNV <i>G. bimaculatus nudivirus</i>	nudi (DNA)	<i>G. campestris</i> , <i>G. bimaculatus</i> , <i>T. oceanicus</i> , <i>T. commodus</i>
AdVV <i>A.domesticus volvovirus</i>	? ssDNA	<i>A.domesticus</i> , <i>G. assimilis</i>
AdMADV <i>A.domesticus mini ambidensovirus</i>	parvo (DNA)	<i>A.domesticus</i>

→ No primary fish pathogens seen

Baculovirus-infected *Spodoptera exigua* larvae

(picture: Courtesy Just Vlask, in Eilenberg et al., 2015)



Potential zoonotic pathogens in insect branch?

- Insect **viruses**: not harmful to humans
- Most **bacteria** from insects and substrate are not harmful to humans (FAO, 2013)
- **Food zoonotic bacteria**: *Salmonella*, *Campylobacter*, some *E.coli*, mostly low in number in insects, HACCP
- **Fungi**: not primary pathogenic to humans, toxins might be harmful?
- **Parasites of insects**: so far not harmful to humans
- Insects may be **vector** of contaminations (TSEs, toxins, human viruses...)
- **Still much unexplored**

Analysis: Which problems in Aquaculture (as basis for disease and mortality)?



Fish culture:

- **Mostly:** management problems ➔ direct effect on production ➔ **normal values per risk factor needed**
 - Stocking fish
 - Water quality
 - Feed contents and freshness
 - Culture system and way of practice
 - Hygiene
 - Presence of pathogens
- **Often:** parasites, secondary bacteria
- **Now and then:** primary fish pathogens



Vision: HAS, insect/fish/feed branch, and WBVR:

- After **insight** in the problems (inventarisation of risk factors with the **branch**) ➔ **research** of risk factors (applied) ➔
- Develop a basis **Aquaculture health monitoring system**, met production and health indicators for high quality **HAS-education and HAS- and WBVR–research**
- Work according to **GMP**/mode of practice for aquaculture/insect branch by students (field data and field samples)
- **Help improve aquaculture- and insect-branches through applied field research, exchange of knowledge and education**
- **Example:** test for bacteria and fungi at various sites at a cricket farm, check for potential zoonotic or insect or fish pathogens

Aimed results INVIS lectorship

- **A healthy, sustainable and safe chain for culture of insects and fish, using insects in fish feed**
- Knowledge development in this field and of fish feed, **GMP**
- Sharing knowledge between partners and these branches
- Extension and improvement of applied education and research HAS and WBVR
- Joint (national and international) publications
- Spin off projects with other **(inter)national** partners
- On the longer term possibly a **diagnostic insect lab** at WBVR?

Networks, cooperation

Insect network



Fish feed and fish culture

Het eetbare insecten-netwerk is er al...

Logos in the collage include: Venik, INSECT CENTRE, ipiff, NGN, Proti-Farm, kreca, WAGENINGEN UR, jki, Universiteit Utrecht, has, FWO, European Commission, Rijksoverheid, Provincie Noord-Brabant, ZLTO, Green Deal, and samenwerken.

Logos in the collage include: NEVEVI, provimi, DSM, Clubgreen, Duurzaam Paling Fonds, MERCK, SKRETTING, trouw nutrition, and WAGENINGEN UNIVERSITY & RESEARCH.

The international field

- **KU Copenhagen**, Denmark, group Prof. Eilenberg: **insect diseases**
- Thomas More Campus, **KU Leuven**, Belgium, group Prof. Van Campenhout: **food safety**
- **WU Wageningen**, NL: **insect viruses**
- **COST Insects**: resubmitted: Michelle Epstein, **Uni Vienna**, Austria, and many partners
- Interested partners: CEFAS (UK), Warmia and Mazury (Poland), Stellenbosch University (South-Africa), and Rajiv Gandhi University (India), Julius Kühn Institute (D), a.o.



What is IPIFF? International Platform Insects for Feed & Food since 2012

- Pan-European alliance of key players in the insect industry
- Part of the DG SANTE Advisory Working Group
- Promoting insects as top-tier source of animal proteins for feed & food
- Developing standards & best practices
- Advocating for appropriate legislative frameworks for insect nutrition
- Supporting high-level and collaborative R&D
- Working groups on feed & food

IPIFF


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 SUPRO2 / COSMOS
> Food / Feed

 BIOCONVAL / FLYING FOOD
> Food / Feed

 WAGENINGEN UR
 Proti-Farm

 ICROFS
 Proti-Farm

 AQUAFLY
> Aquafeed

  FiBL
> Feed

 CHITINSECT
> Coating

 NIFES  PROTIX

 PROteINSECT
INSECTS AS SUSTAINABLE SOURCES OF PROTEIN
> Feed

 Desirable
insect biorefinery
> Feed

 EDIBLE FOREST INSECTS
> Food

 Ecodiptera
Life
> Fertilizers

 CHITINTERESTING
> Coating

 Rep Polytechnic
> Feed

 bioflytech
UNIVERSITY & RESEARCH

Conclusions - Our plan?

- The edible insect branch for food en feed is growing fast
- Black Soldier Fly larvae meal to replace fish meal in salmon feed promising
- Branch is accepted as official animal husbandry
- EU legislation developing, chicken branch to follow
- Health and disease risks seem to be low, but need to be further investigated
- Extend int. network on disease experts of edible insects
- Further investigate which pathogens ➡ tests needed?
- Which NRLs are interested?

We are on the move, please join in!

Thank you!



Some pictures and data thanks to **New Generation Nutrition** NGN, Marian Peters, Wageningen, and **Proti-Farm Holding BV**, Heidi de Bruin, Ermelo, NL



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