Lumpfish genetic research

Dr. Ólöf Dóra Bartels Jónsdóttir, Dr. Albert Imsland (Akvaplan-niva), aki@akvaplan.niva.no Dr. Simo Maduna & Dr. Snorre Hagen (NIBIO) Dr. Patrick Reynolds (GIFAS)

Nordic Salmon 27. October 2021

Akvaplan.

Is lice grazing genetically controlled ?

- Percentage grazing on lice increases from 10 to 36%
- Still over 60% who don't eat lice?
- Large individual differences in lice grazing
- Can we teach lumpfish to eat lice?
- Is it possible to select for lice grazing?



Proposal for breeding program on lumpfish-CYCLOSELECT

- Classical approach
 - Production and testing of different family groups (APN og Gifas)
- Molecular methods (APN, NIBIO)
- Industry partners: Lerøy/SAS, Lumarine, Nordlaks Oppdrett



Akvapla

The basic layout in CYCLOSELECT



Implementation of CYCLOSELECT

✓ Now the proportion of lice grazers is between 0-42%

✓ That is, for every 100 NOK kr that goes to the purchase of lumpfish, a maximum of 40 NOK kr is used for delousing

✓ If we can get this share up to 70-80% we will increase the sales value of the lumpfish fry produced

Implementation of CYCLOSELECT

Akva

✓ Increased survival and more robust fish

✓ Increased proportion of lice grazers (up to 70-80%)

✓ Summarized:

✓ We estimate the value of the implementation of the project for industrial partner around 5-10 m NOK annually per 1 m fry under the first and second generation (G) of the breeding project

First published trial

Akvaplan

(Imsland et al. 2016, Aquaculture 459, 156-165)



- □ More than 80% net reduction in lice on salmon in cages 3 and 8
- □ These cages had the "lice eating family" present
- □ Significant maternal and paternal effect, so selection is possible

Akvaplan

H18 trial – Lice grazing in different lumpfish families



Sea pen nr. 207 (with families F5 og 6) shows clearest lice grazing

> 46-68% lower lice numbers in cages with family 5 and 6 present



Family trials – publications Aquaculture 530 (2021) 735925 Aquaculture 459 (2016) 156-165 Contents lists available at ScienceDirect quacultur Contents lists available at ScienceDirect Aquaculture Aquaculture journal homepage: www.elsevier.com/locate/aquaculture journal homepage: www.elsevier.com/locate/aquaculture Quantification of grazing efficacy, growth and health score of different Is cleaning behaviour in lumpfish (Cyclopterus lumpus) CrossMark lumpfish (Cyclopterus lumpus L.) families: Possible size and gender effects parentally controlled? Albert Kjartan Dagbjartarson Imsland^{0,b,e,1}, Patrick Reynolds^{C,1}, Thor Arne Hangstad^d, Albert K. Imsland a.b.*.1, Patrick Reynolds c.1, Gerhard Eliassen c, Atle Mortensen d, Øyvind J. Hansen d, Lauri Kaparid, Simo Njabulo Madunad, Snorre B. Hagend, Ólöf Dóra Bartels Jónsdóttird, Velmurugu Puvanendran^d, Thor Arne Hangstad^e, Ólöf D.B. Jónsdóttir^a, Per-Arne Emaus^e, Frank Spetland¹, Ken Ståle Lindberg⁸ Tor Anders Elvegård^F, Sebastiaan C.A. Lemmens^g, Randi Rydland^h, Ane V. Nytrø^e, Thor Magne Jonassen^e * Akvaplan-niva Iceland Office, Akralind 4, 201 Kópavogur, Iceland ^a Akvaplan-niva Iceland Office, Akralind 4, 201 Kópavogur, Iceland ^b Department of Biology, University of Bergen, High Technology Centre, 5020 Bergen, Norway ^b Department of Biosciences, University of Bergen, High Technology Centre, 5020 Bergen, Norway GIFAS AS, Gildeskål, 8140 Inndyr, Norway GIFAS AS, Gildeskál, 8140 Inndyr, Norway ^d Akvaplan-niva, Framsenteret, 9296 Tromsø, Norway ^d Nofima, Muninbakken 9-13, Breivika, 9291 Tromse, Norway Norwegian Institute of Bioeconomy Research, Svanhovd, 9925 Svanvik, Norway * Akvaplan-niva, Framsenteret, 9296 Tromsa, Norway Lumarine AS, Stadionveien 21, 4632 Kristiansand, Norway Nordlaks Oppdrett AS, Post box 224, 8455 Stokmarknes, Norway ⁸ Senja Akvakultursenter AS, Rubbestadveien 401, 9304, Vangsvik, Norway ⁸ Lerøy Midt, Hestvika, Norway * Grieg Seafood Finnmark AS, Markedsgata 3, Alta, Norway

Our trials show that it is possible to significally increase lice grazing through genetic selection

We also see clear effect in disease resistance and survival

Lumpfish genomics Strategy for identifying genes underlying economically important traits





A) Population Genomics: SNPs and Microsatellites (g-STR and EST-STRs)







- To apply a seascape genomics framework to detect patterns of local adaptations
- Genome-wide SNP genotyping using 3RADseq was carried out for 206 individuals for 14 global sampling populations
- 3RADseq data was successfully generated and currently undergoing quality control





Population Genomics – Norwegian coast (different samples) - 10,586 SNPs





B) Linkage mapping – positions of genes on chromosomes



Akvaplan

C) Genetic dissection of traits





- 2018-Families 1, -2, -5, -6 and -10 selected to comprise the mapping population segregating for :
 - Growth-related traits (BW, SGR)
 - Health-related traits (cataract severity, eye ulceration)
 - Foraging-related traits (Sea-lice grazing)
- SNP genotyping using the 3RADseq protocol has been completed and sequencing data has been successfully generated

Objectives



Phase 1: Development of molecular genetic markers (DNA polymorphisms that segregates in a given population)

Phase 2: Linkage mapping

(Defining the position of known genes or genetic markers relative to each other along the length of all chromosomes in terms of recombination rate)

Phase 3: Quantitative traits loci (QTL) and GWAS analyses (Identifying genes and/or regulatory regions, and the causal variants underlying complex traits)

Phase 4: Marker-assisted selection (MAS) breeding (Efficient genetic improvement of broodstock for economically important traits)



Genetic research – publications

Aquacult Int (2018) 26:49-60 DOI 10.1007/s10499-017-0194-2



Population genetic structure of lumpfish along the Norwegian coast: aquaculture implications

Ólöf Dóra Bartels Jónsdóttir¹ • Julia Schregel² • Snorre B. Hagen² • Camilla Tobiassen² • Siv Grethe Aarnes² • Albert K. D. Imsland^{1,3}

Received: 24 May 2017 / Accepted: 8 September 2017 / Published online: 17 September 2017 © Springer International Publishing AG 2017 www.nature.com/scientificreports

SCIENTIFIC REPORTS

Akvapla

OPEN Genome- and transcriptomederived microsatellite loci in lumpfish *Cyclopterus lumpus*: molecular tools for aquaculture, conservation and fisheries management

> Simo N. Maduna 💬^{1*}, Adam Vivian-Smith 🖸², Ólöf Dóra Bartels Jónsdóttir³, Albert K. D. Imsland^{3,4}, Cornelya F. C. Klütsch¹, Tommi Nyman¹, Hans Geir Eiken¹& Snorre B. Hagen^{1*}

