

Aquaculture genetic breeding in China

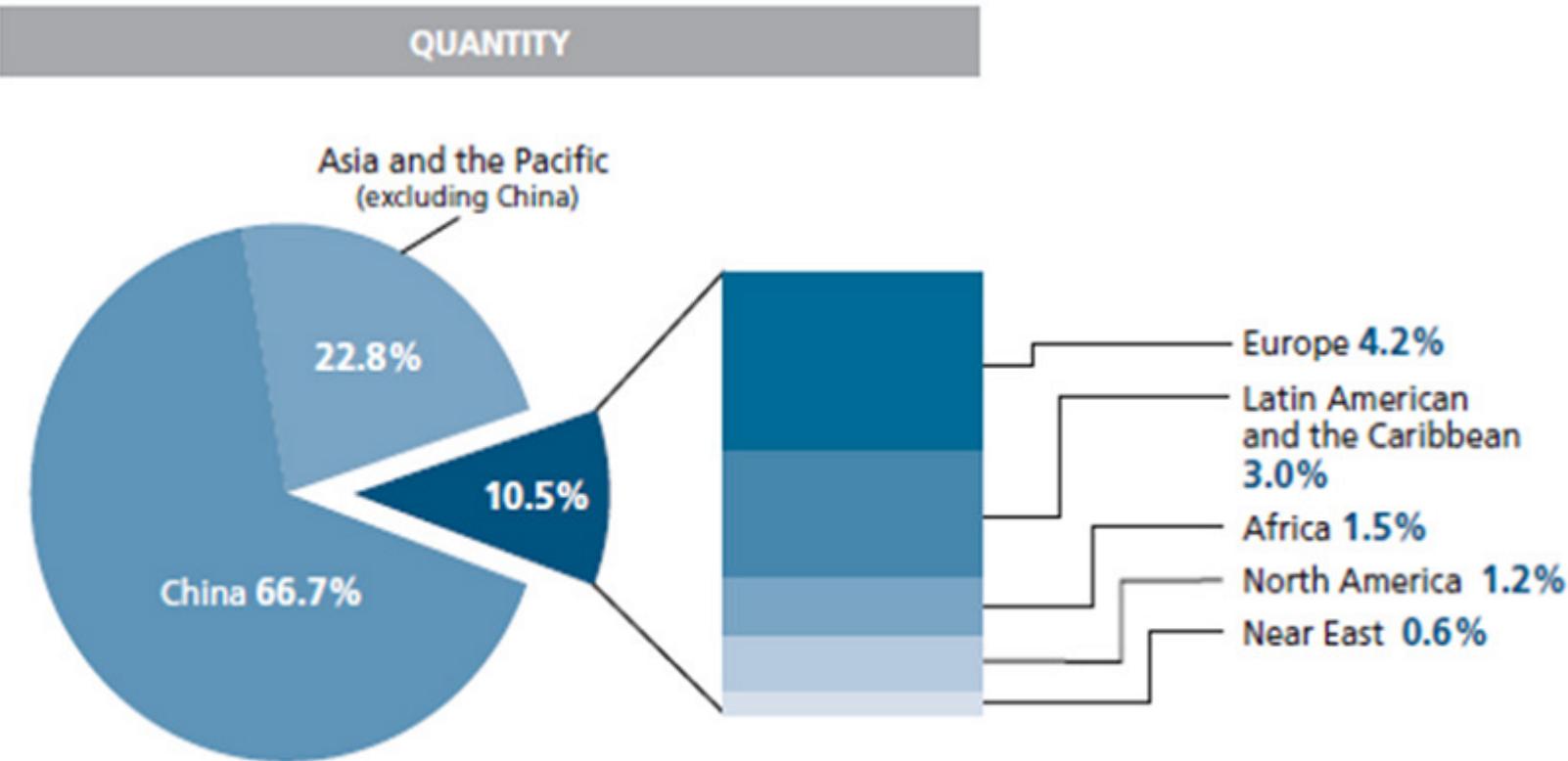
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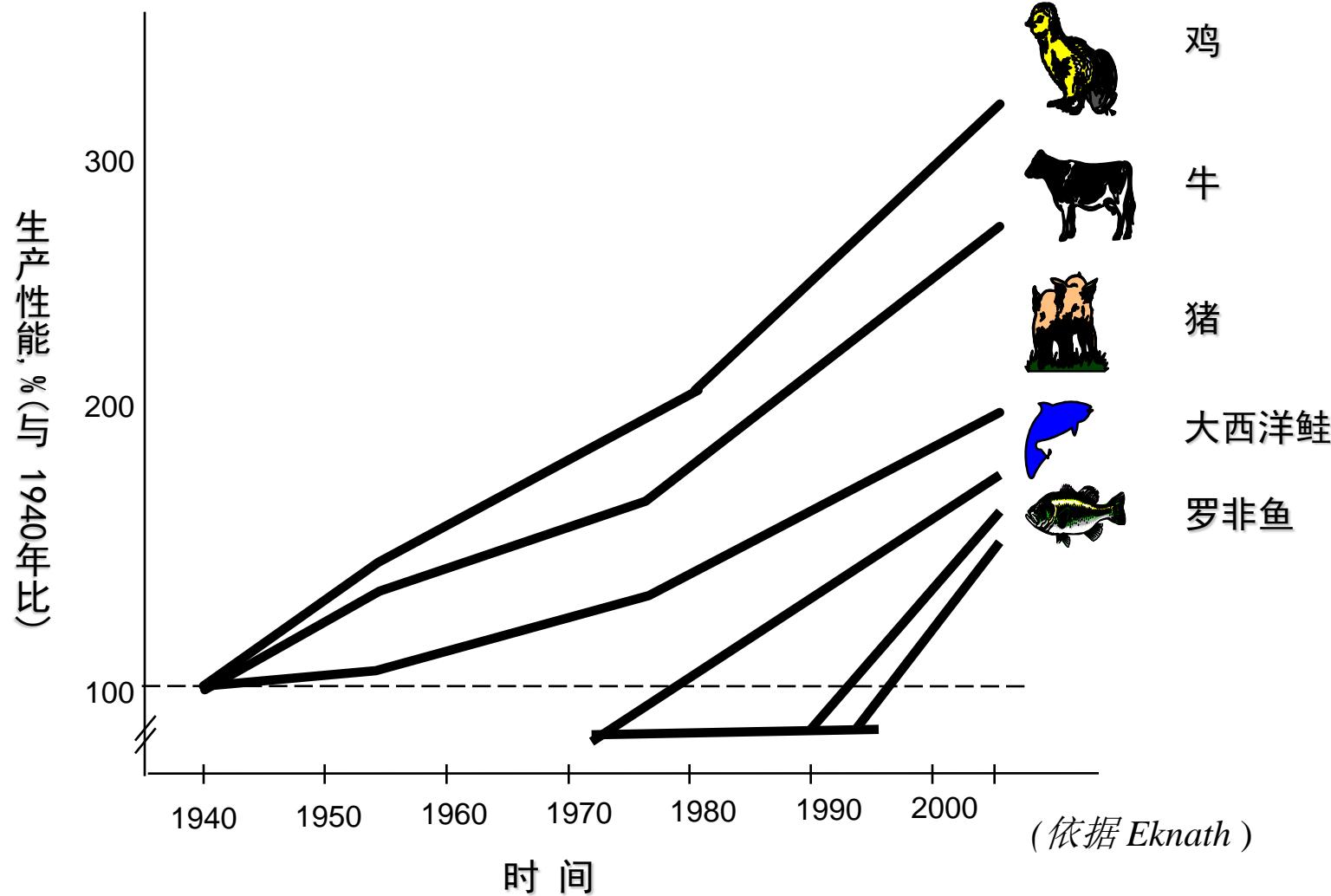
Contribution of China to the world aquaculture production



World production: 52 million tonnes with a value of US\$ 78.8 billion

(FAO, 2009)

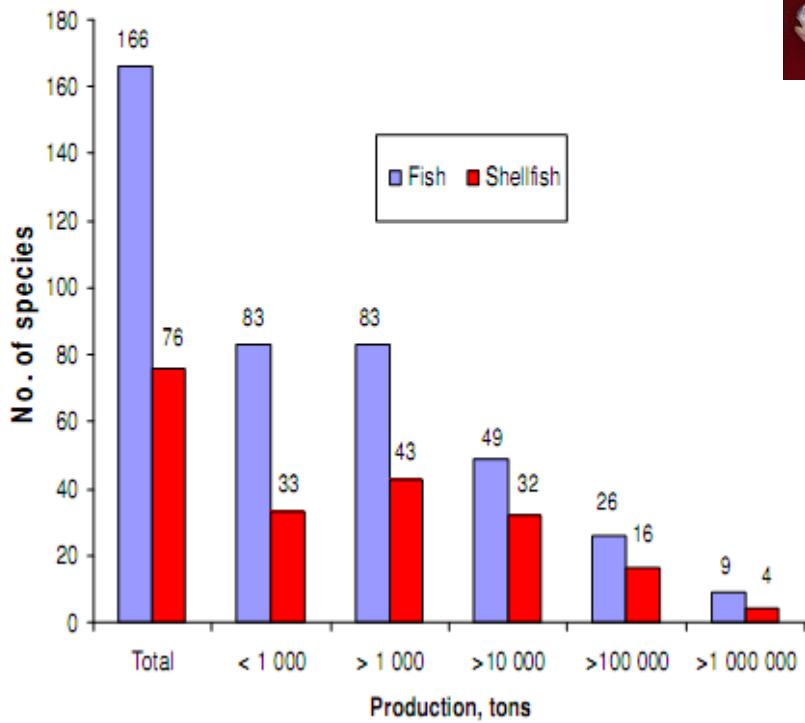
世界育种成就



High diversity of aquacultural species

Aquaculture:

- 240 species farmed
- 42 species > 100 000 tons
- 13 species > 1 mill tons



FAO (2005)



Aquacultural varieties bred in China

Five selective breeding projects



Breeding Strategies--shrimp

Composite Base Population:

- high genetic quality
- broad additive genetic diversity

Design and Control Mating

Individual Spawning/Hatching

Marking and Tagging

Testing:

- Growth/survival in commercial ponds
- WSSV-challenge Testing

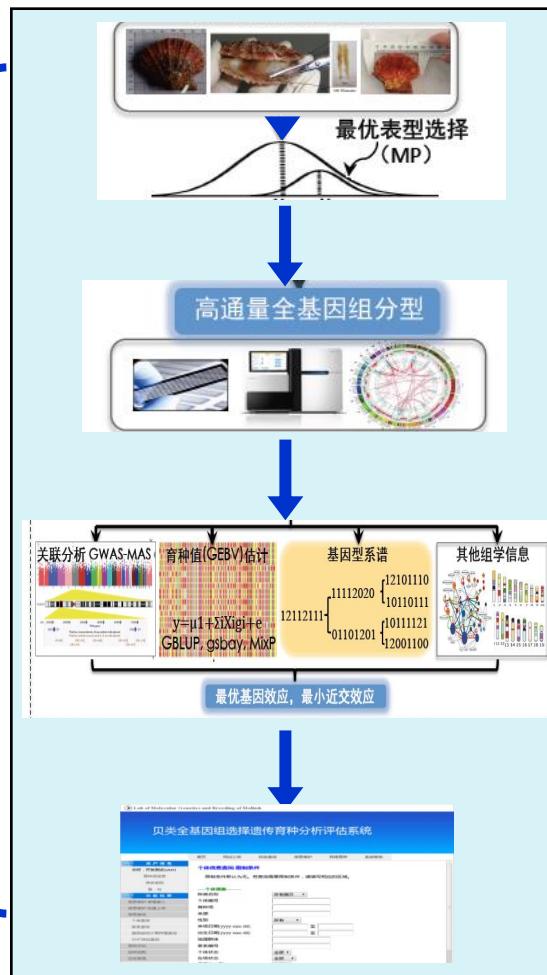
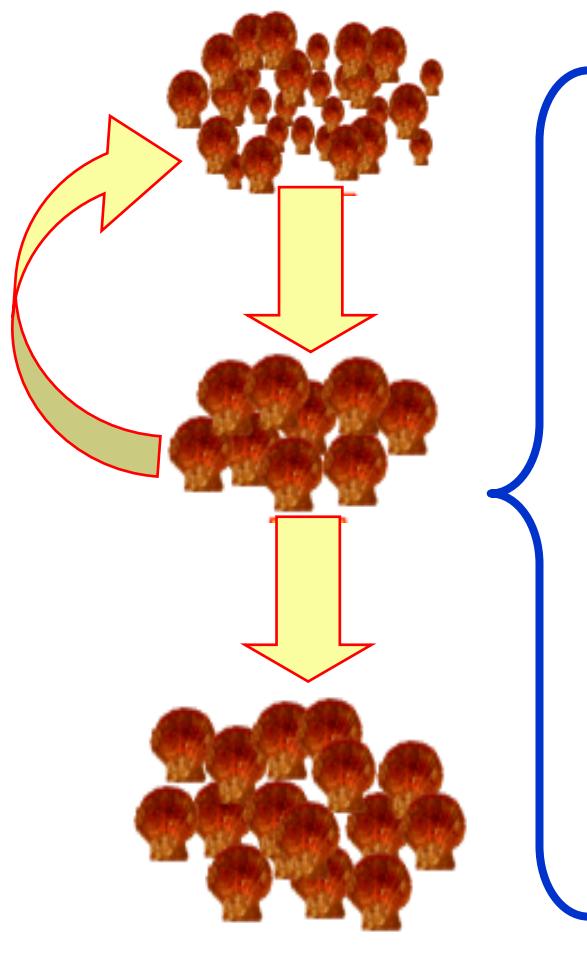
Calculate Selection Index



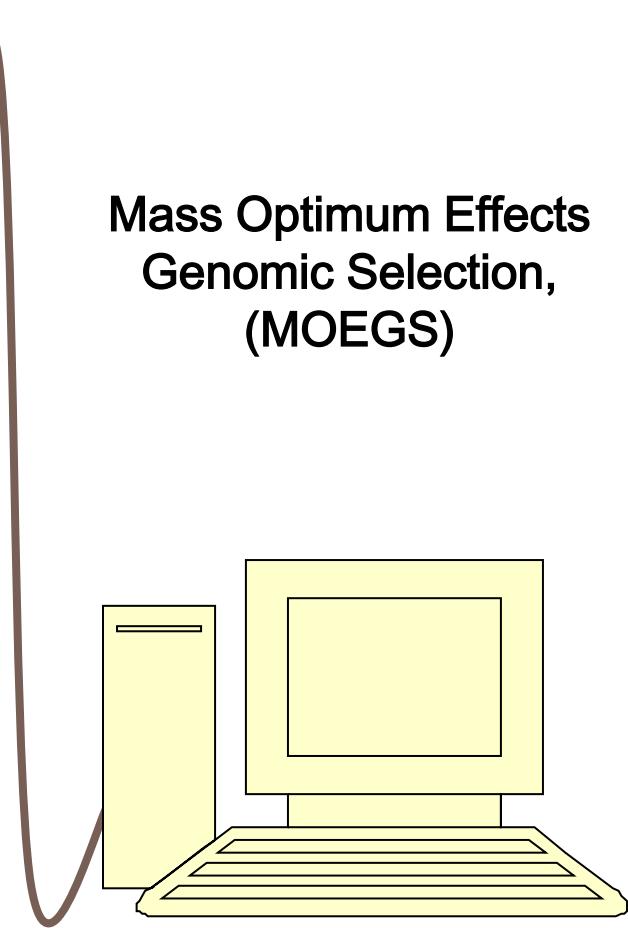
Key procedures of scallop breeding



Novel GS approach applied in scallop



Mass Optimum Effects
Genomic Selection,
(MOEGS)



Hatching facility for fish



Turbot



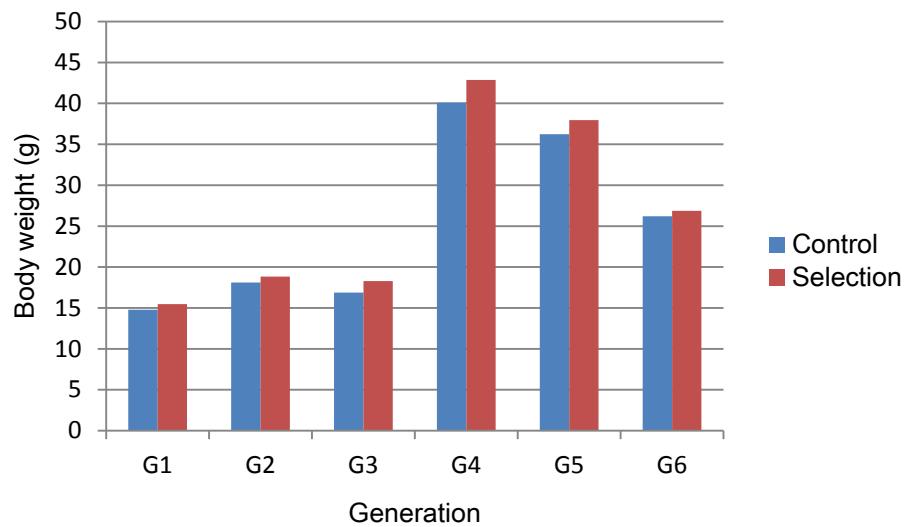
Cat fish



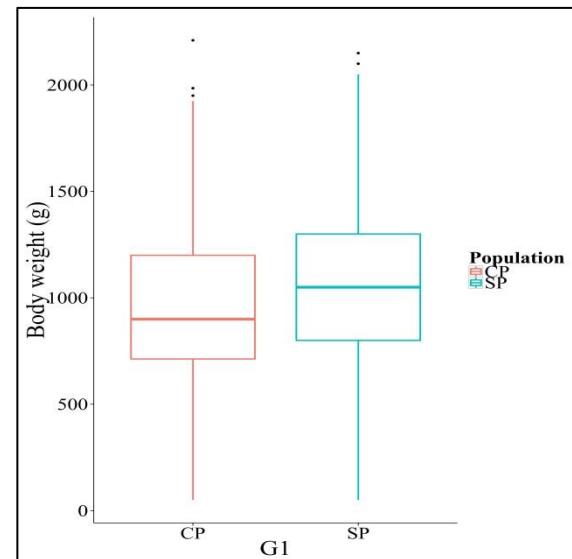
Genetic parameters

Trait	Species	Heritability	Common environment
		$h^2 \pm se$	$c^2 \pm se$
Body weight	Chinese shrimp	0.180±0.050	0.160±0.020
	Pacific white shrimp	0.350±0.080	0.070±0.030
	Giant freshwater prawn	0.056±0.014	0.039±0.005
	Channel catfish	0.225±0.083	0.129±0.036
Survival	Turbot	0.560±0.150	0.042±0.045
	Chinese shrimp	0.030±0.021	0.060±0.032
	Pacific white shrimp	0.051±0.034	0.093±0.018
	Giant freshwater prawn	0.016±0.012	0.092±0.007
WSSV resistance	Channel catfish	0.280±0.048	-
	Turbot	0.120±0.030	-
Temperature tolerance	Chinese shrimp	0.140±0.120	-
Temperature tolerance	Turbot	0.055±0.035	0.027 ±0.066

Genetic gain with multiple generations



**Accumulated genetic gain:
30.48% for six generations
of selection.**



**Accumulated genetic
gain: 11.71% for one
generation of selection.**



Measuring genetic gain using the wild population

species	Generation	Population	Least square means (g)	Selection response (%)
Chinese shrimp	G ₇	Selection	17.10	18.67
		Wild	14.41	
Giant freshwater prawn	G ₃	Selection	18.63	39.76
		Wild	13.33	
	G ₆	Selection	26.87	39.95
		Wild	19.20	

Data management

- Data is essential component
 - Pedigree records
 - Performance records



- Data system is required:
 - Purpose-built database
 - Standard file imports and exports
 - Output for genetic analysis and breeding decisions

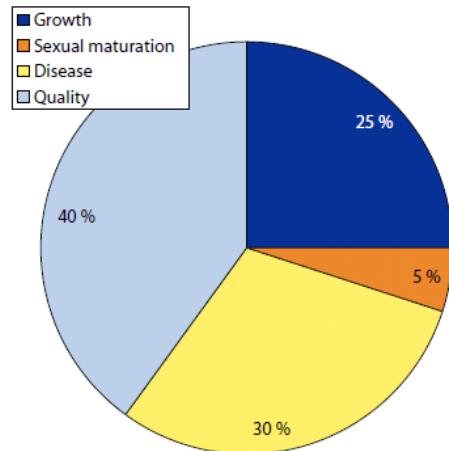


水产竞争效能测试家系分配系统									
序号	家系名	平均产卵量	平均受精率	平均存活率	平均成活率	平均生长率	平均增重	平均死亡率	备注
001	YH01_01	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
002	YH01_02	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
003	YH01_03	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
004	YH01_04	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
005	YH01_05	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
006	YH01_06	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
007	YH01_07	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
008	YH01_08	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
009	YH01_09	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
010	YH01_10	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
011	YH01_11	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
012	YH01_12	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
013	YH01_13	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
014	YH01_14	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
015	YH01_15	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
016	YH01_16	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
017	YH01_17	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
018	YH01_18	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
019	YH01_19	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
020	YH01_20	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
021	YH01_21	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
022	YH01_22	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
023	YH01_23	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
024	YH01_24	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
025	YH01_25	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
026	YH01_26	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
027	YH01_27	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
028	YH01_28	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
029	YH01_29	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
030	YH01_30	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
031	YH01_31	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
032	YH01_32	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
033	YH01_33	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
034	YH01_34	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
035	YH01_35	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
036	YH01_36	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
037	YH01_37	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
038	YH01_38	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
039	YH01_39	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
040	YH01_40	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
041	YH01_41	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
042	YH01_42	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
043	YH01_43	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
044	YH01_44	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
045	YH01_45	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
046	YH01_46	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
047	YH01_47	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
048	YH01_48	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
049	YH01_49	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
050	YH01_50	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
051	YH01_51	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
052	YH01_52	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
053	YH01_53	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
054	YH01_54	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
055	YH01_55	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
056	YH01_56	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
057	YH01_57	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
058	YH01_58	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
059	YH01_59	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
060	YH01_60	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
061	YH01_61	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
062	YH01_62	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
063	YH01_63	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
064	YH01_64	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
065	YH01_65	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
066	YH01_66	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
067	YH01_67	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
068	YH01_68	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
069	YH01_69	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
070	YH01_70	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
071	YH01_71	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
072	YH01_72	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
073	YH01_73	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
074	YH01_74	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
075	YH01_75	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
076	YH01_76	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
077	YH01_77	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
078	YH01_78	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
079	YH01_79	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
080	YH01_80	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
081	YH01_81	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
082	YH01_82	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
083	YH01_83	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
084	YH01_84	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
085	YH01_85	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
086	YH01_86	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
087	YH01_87	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
088	YH01_88	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
089	YH01_89	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
090	YH01_90	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
091	YH01_91	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
092	YH01_92	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
093	YH01_93	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
094	YH01_94	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
095	YH01_95	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
096	YH01_96	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
097	YH01_97	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
098	YH01_98	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
099	YH01_99	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
100	YH01_100	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
101	YH01_101	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
102	YH01_102	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
103	YH01_103	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
104	YH01_104	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
105	YH01_105	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
106	YH01_106	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
107	YH01_107	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
108	YH01_108	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
109	YH01_109	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
110	YH01_110	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
111	YH01_111	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
112	YH01_112	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
113	YH01_113	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%
114	YH01_114	2.44	0.98%	0.98%	0.98%	0.98%	0.98%	0.02%	0.00%

Future developments

1. multi-trait selection technology.

- Growth rate, feed efficiency, disease resistance, resistance to adverse environments (temperature, salinity, ammonia nitrogen), sexual maturation and quality.
- Genotype by environment interaction.
- Move towards more balanced breeding objectives.

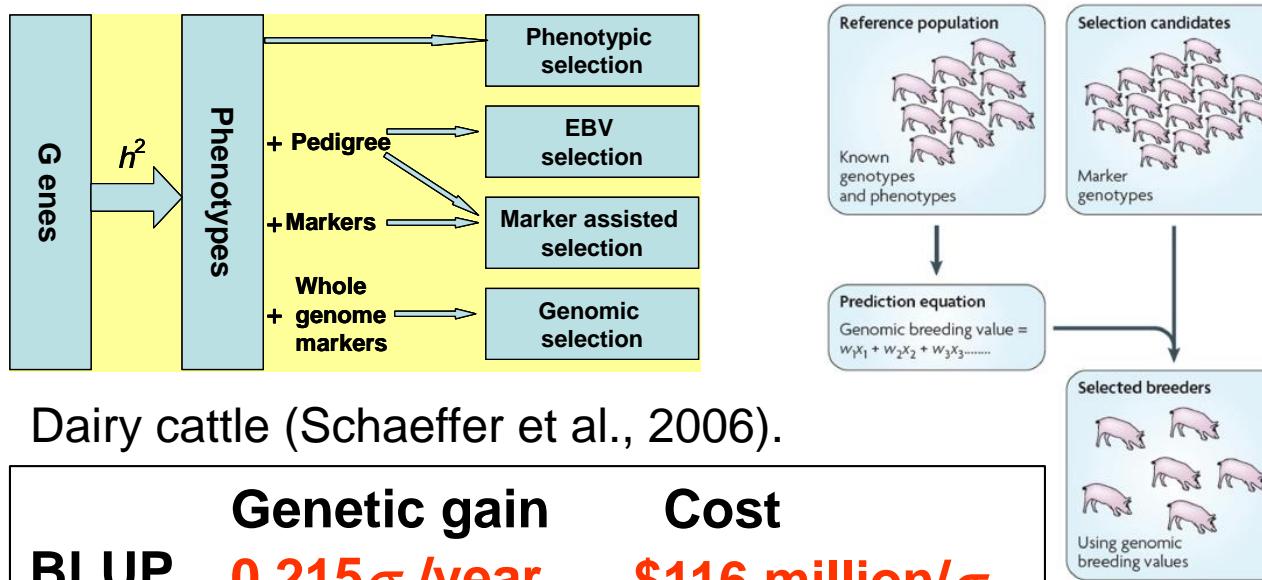


Main-trait	Sub-trait	Main weighting	Partial weighting
Growth	Smolt weight	25	5
	Slaughter weight		20
Sexual maturation		5	5
	Disease	30	
Quality	IPN		10
	ISA		15
	Furunculosis		5
	Filet colour	40	20
	Body shape		5
	Total fat		10
	Visible fat		5
	Total	100	100

Example of increasing number of trait in the AquaGen population

2. The future of a genome-wide association study and the whole genome selection in aquaculture

- Increased genetic gain (increasing accuracy of selection; reducing the generation interval)
- Lower inbreeding rate per generation



Dairy cattle (Schaeffer et al., 2006).

	Genetic gain	Cost
BLUP	$0.215\sigma_g/\text{year}$	\$116 million/ σ_g
GS	$0.467\sigma_g/\text{year}$	\$4.17 million/ σ_g

Thank you !

