Morphological quality assessment of reared juveniles from Mediterranean aquaculture

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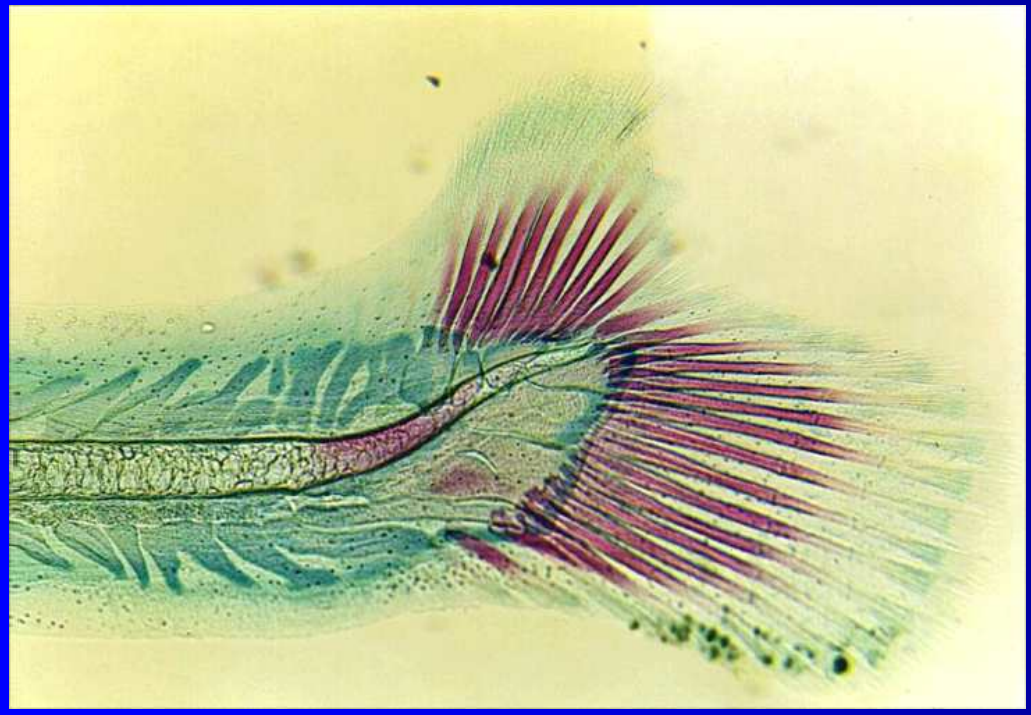
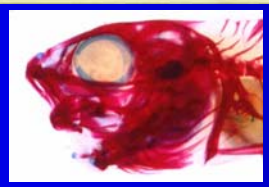
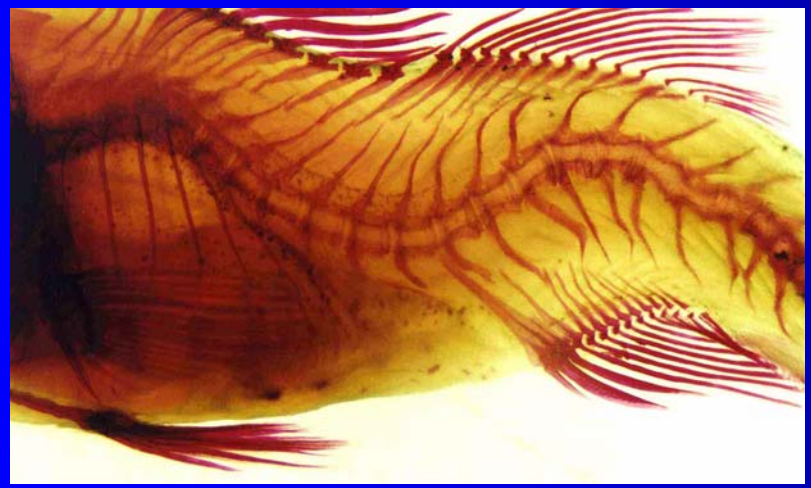






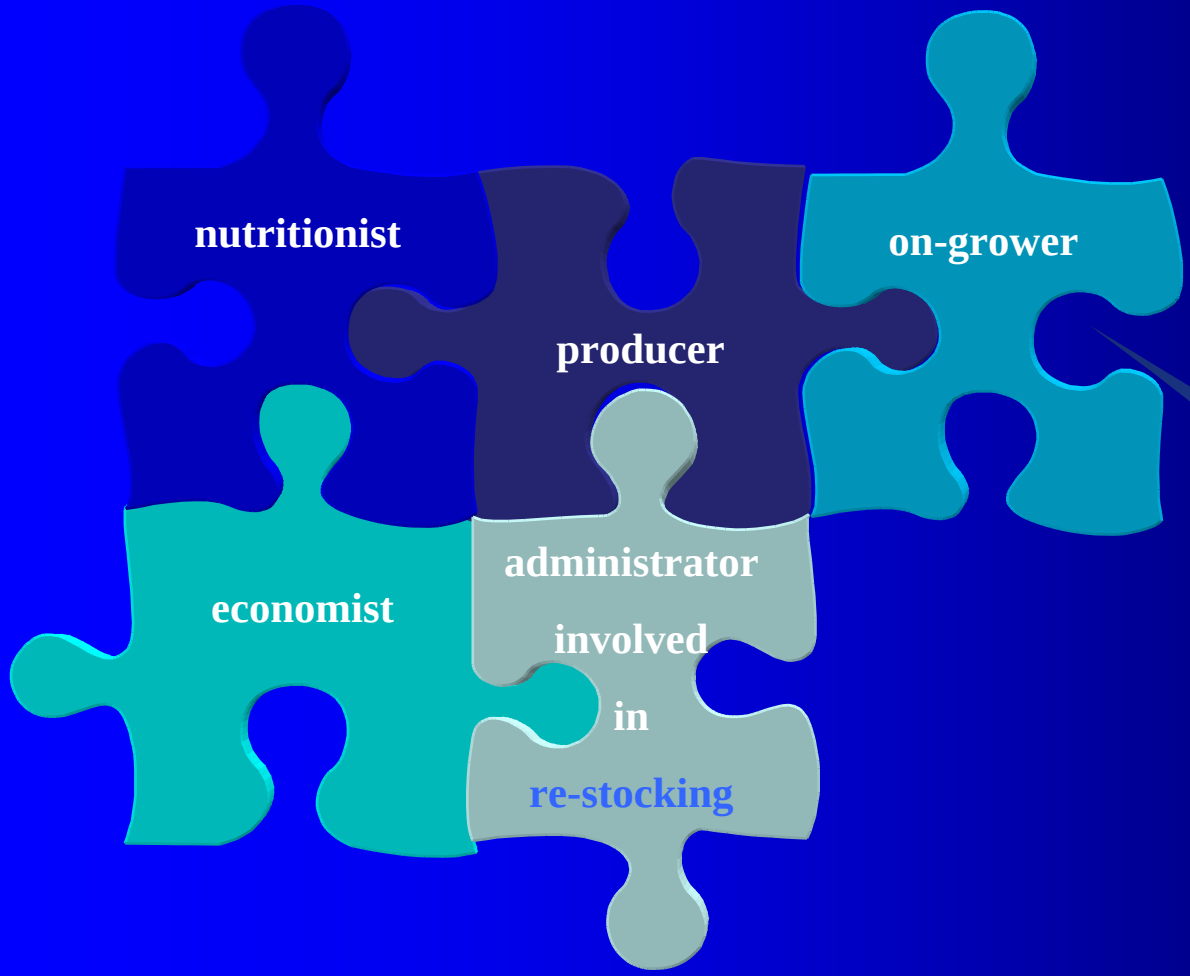
Labelling will play an increasing role to save high quality productions

The quality

- According to the standard ISO 8402, Quality is “the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs.”

- Aquaculturists: safety and sensory quality
- Ornamental fish: fish health certification

Fry quality



- *A GOOD quality criterion should be able to describe as accurately as possible a specific characteristic.*
- *An EXCELLENT has also predictive abilities.*

Fry quality criteria

Morphological criteria

- **What they ‘describe’ ?**
- **Which of morphological criteria are good quality descriptors ?**
- **What is the appropriate standard reference for morphological quality ?**
- **Have they predictive ability ?**

What they ‘describe’?

GENOTYPE

+

EPIGENETIC FACTORS

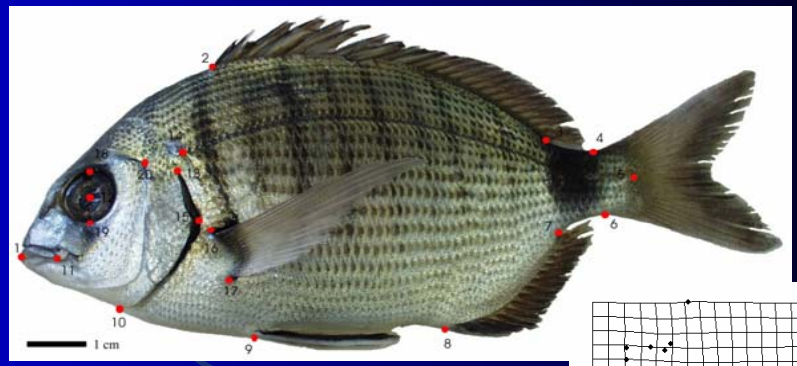
- **Temperature**
- **Salinity**
- **Density**
- **Alimentation**
- **Handling**
- **.....**

+

DEVELOPMENTAL HOMEOSTASIS

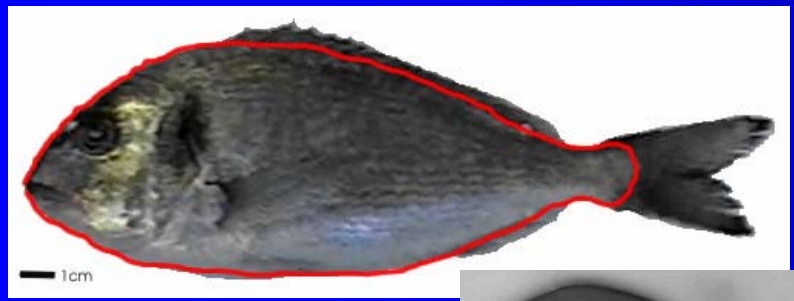
PHENOTYPE

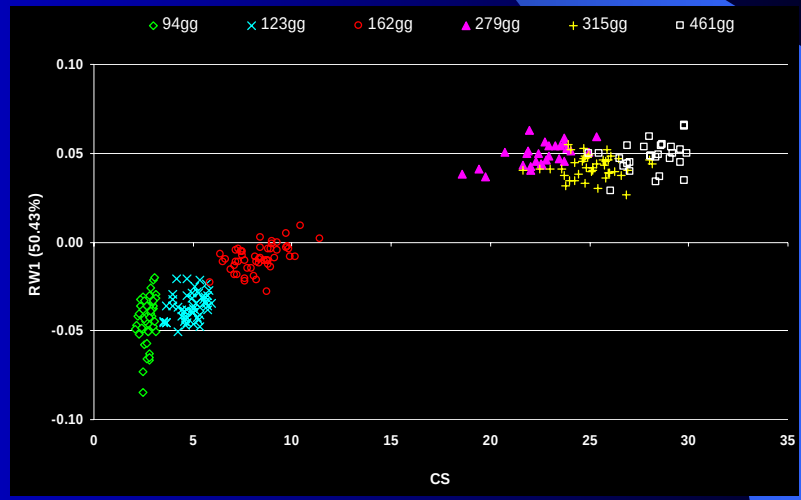
Which of morphological criteria are good quality descriptors ?



Geometric Morphometrics

Is a landmark (point of homology) based technique
Allow the visualization of the local variation of shape through splines
Allow to quantify shape variation through statistical analysis
Allow to relate shape to external variables

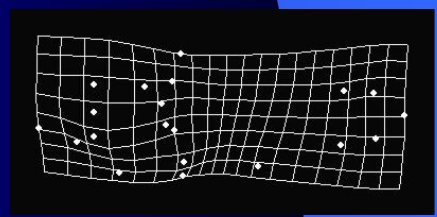


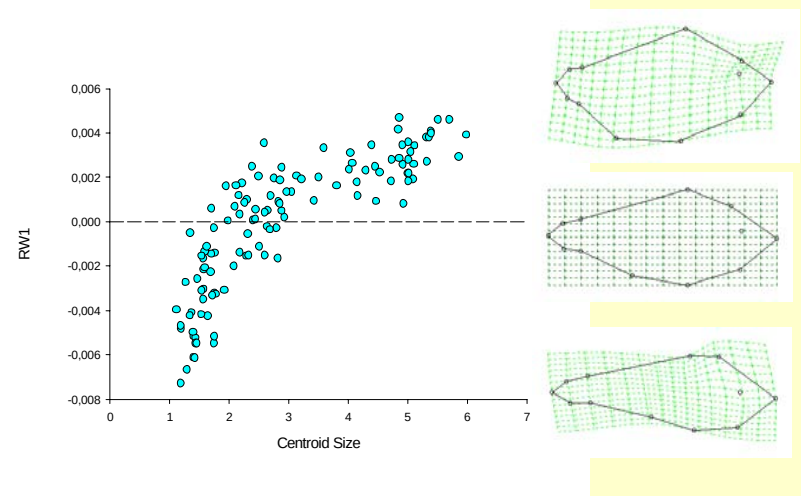


Elliptic Fourier Analysis

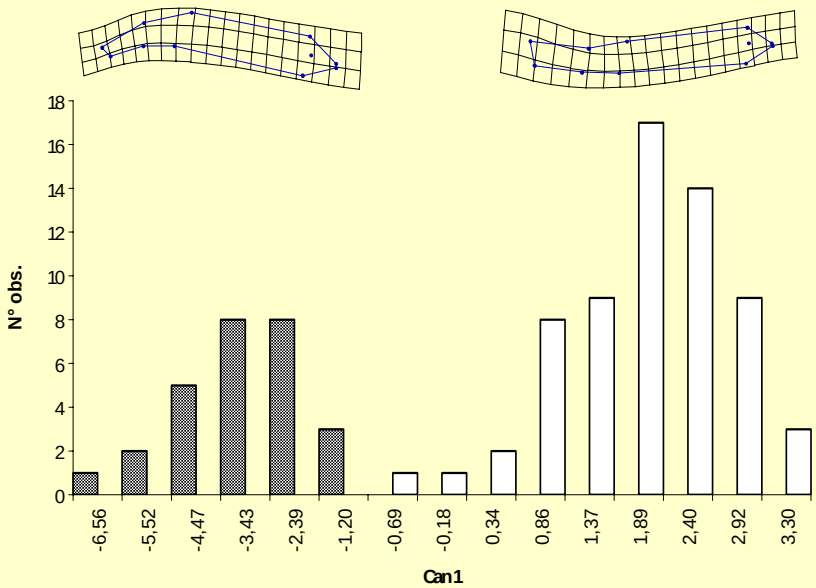
Is a technique based on closed contours, that could be automatically extracted
Allow the visualization of the global variation of shape
Allow to quantify shape variation through statistical analysis
Allow to extract equations that describe the “mean” shape of each group

The growth trajectory of *Sparus aurata*. Shape (Y axis) changes rapidly in relation to size (X axis) from fry (94 d.p.h.) to sub-adults (461 d.p.h)

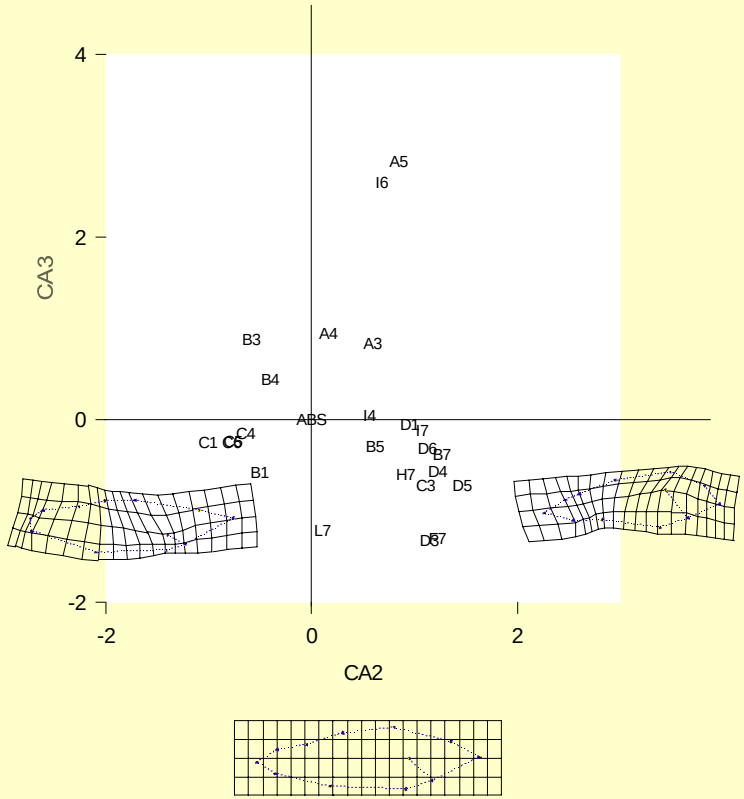




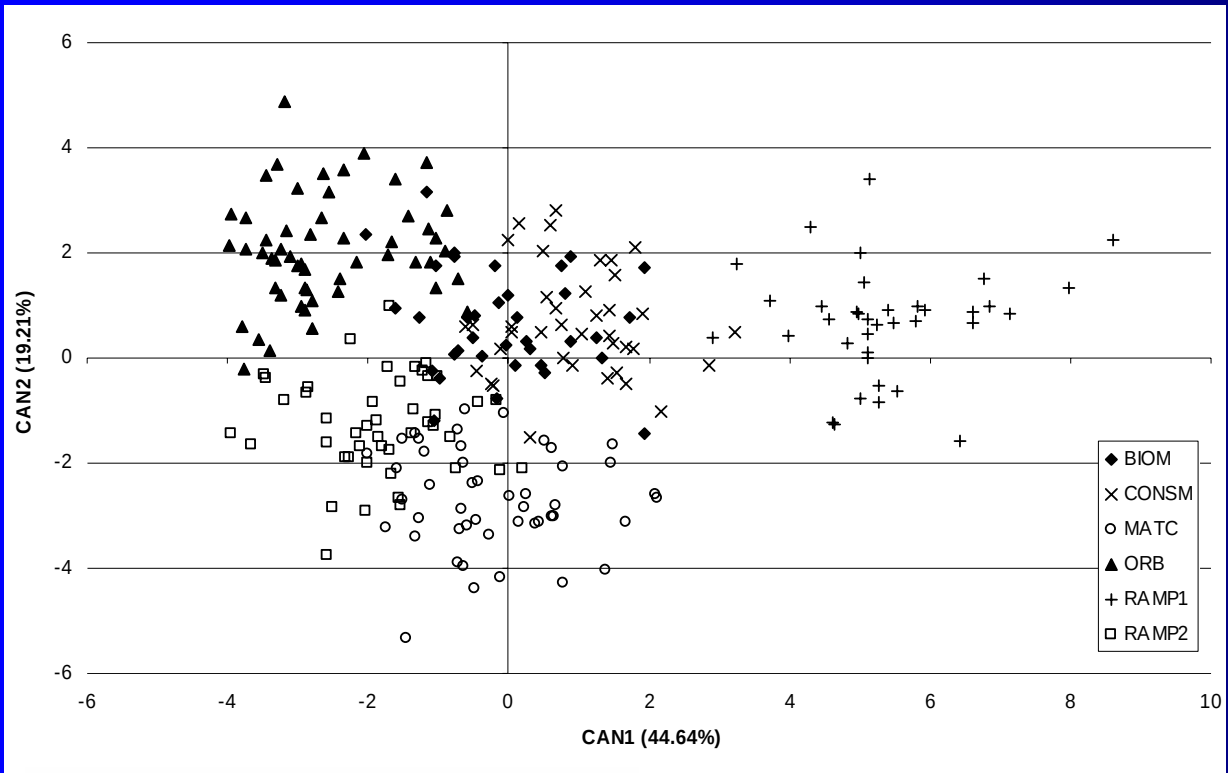
The growth trajectory of *Diplodus puntazzo*. Shape (Y axis) changes rapidly in relation to size (X axis) during the early juvenile planktonic stage and isometry is reached when specimens settle on substrate.

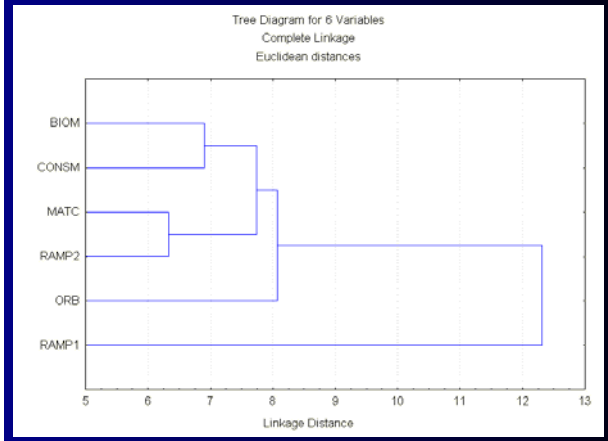


Shape differences in the sea bass, *Dicentrarchus labrax*, reared in different conditions. Above, shape differences between larvae (40 days) reared with traditional intensive techniques (left spline) and with "large volume" techniques.

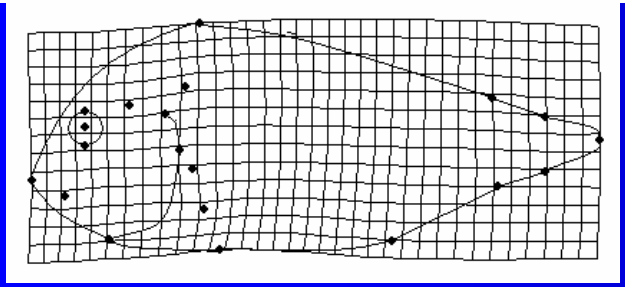


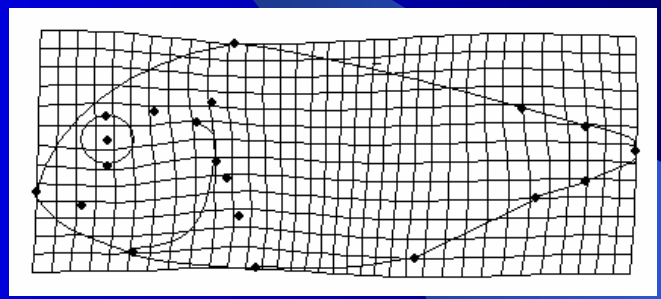
By regressing the parameters of the Thin-plate Spline function on the scores of each individual obtained by the analysis of skeletal anomalies it is possible to visualize characteristic shapes relative to specific onsets of anomalies. The example refers to the case of adult sea bass. The spline at the center of the plot refers to the class of anomalies "ABS" which stands for absence of anomalies and can be use as a term of comparison for quality assessment.



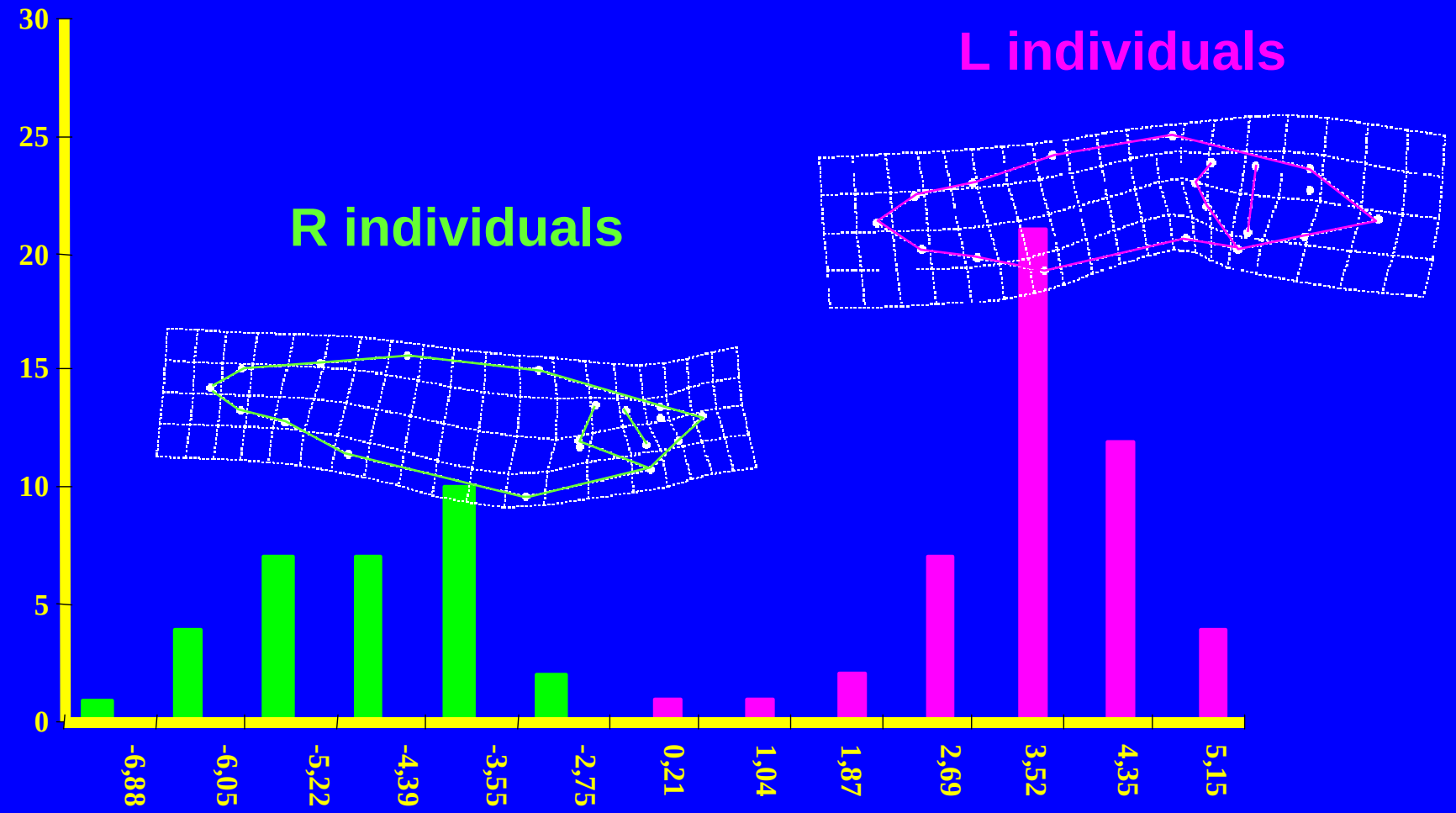


Dendrogram of the same experiment where intensive techniques well separates from ecological semi-intensive mariculture approach.





Shape differences in sub-adult sea bream, *Sparus aurata,* reared in different conditions. Canonical Variates Analysis and splines relative to groups reared with traditional intensive techniques (right spline) and with ecological semi-intensive mariculture approach.


L individuals
R individuals
30
25
20
15
10
5
0
-6,88
-6,05
-5,22
-4,39
-3,55
-2,75
0,21
1,04
1,87
2,69
3,52
4,35
5,15

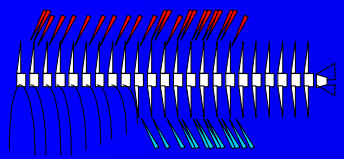
Which of morphological criteria are good quality descriptors ?

SPECIES	WILD n	REARED n
D. labrax	122	2,854 (40-111 days)
S. aurata	160	1,799 (70-125d)
C. labrosus	345	47 (30 d)
D. puntazzo	126	624 (50-100d)
P. erythrynus	0	130 (140-204d)
P.pagrus	0	144 (40-60d)
D. dentex	0	70 (30-60d)
E. marginatus	0	619 (30-110d)

Which of morphological criteria are good quality descriptors ? and ....

What is the appropriate standard reference for morphological quality ?

meristic counts



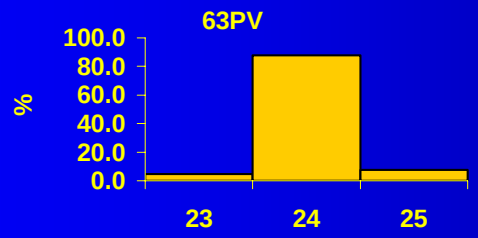
Asymmetries of paired elements

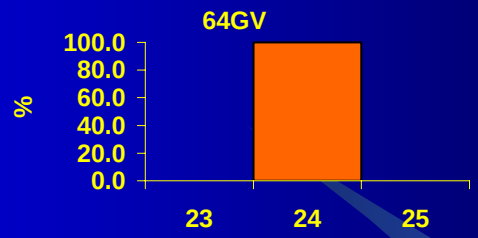
Gilthead sea bream	Pectoral rays		Pectoral radials		Pelvic rays		Total (n)		Total (%)	
lots	Asymm.	Symm.	Asymm.	Symm.	Asymm.	Symm.	Asymm.	Symm.	Asymm.	Symm.
63PV	16	89	2	103	5	100	21	84	20.0	80.0
85PV	10	95	1	104	1	104	11	94	10.5	89.5
64GV	3	37	0	40	3	37	6	34	15.0	85.0
85GV	3	102	2	103	0	105	5	100	4.8	95.2
WILDp	1	40	0	41	0	41	1	40	2.4	97.6

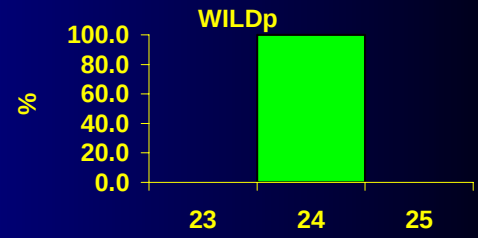
Topography of fin inner bearing

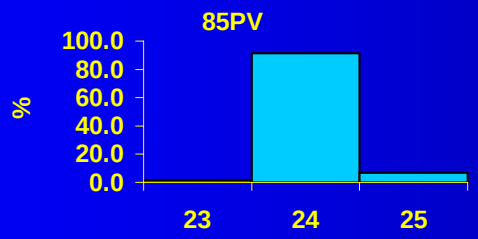
	lots	63 PV	85 PV	64 GV	85 GV	WILDp	WILDg
ANAL FIN	Observed formulae *(n)*	23	22	14	22	7	7
	More common	HZB	HFB	HZB	HZB	HFB	HFB
		26.7	33.3	30.0	31.4	73.2	81.7
		HZA	HZB	HFB	HFB	HFS	HFR
		14.3	22.9	22.5	20.0	9.8	6.7
DORSAL SPINES	Observed formulae *(n)*	7	5	7	9	4	2
	More common	BDA	AC	BDA	BDA	AC	AC
		47.6	60.0	27.5	35.2	90.2	98.3
		AC	ANC	ANA	AC	AB	AE
		21.0	17.1	22.5	29.5	4.8	1.7
DORSAL SOFT RAYS	Observed formulae *(n)*	49	42	24	31	14	11
	More common	CMD	DDA	CMD	CMD	CSA	CSA
		12.4	14.3	17.5	19.0	51.2	70.0
		CMM	CIA	CMI	CMI	CLA-DOE	CLA
		10.5	8.6	15.0	13.3	9.7	8.3

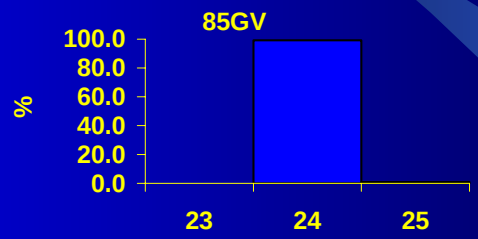
Vertebrae number	63PV	64GV	85PV	85GV	WILDp	WILDg
23	5	0	2	0	0	0
24	92	40	96	104	41	59
25	8	0	7	1	0	1

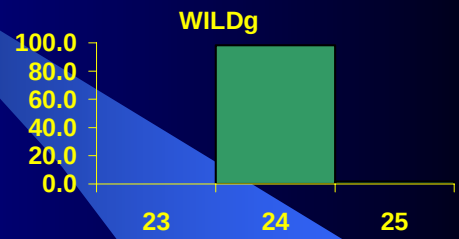




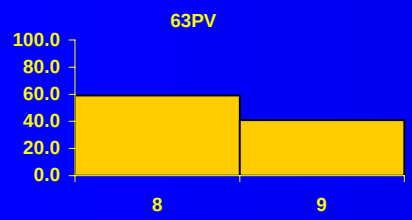


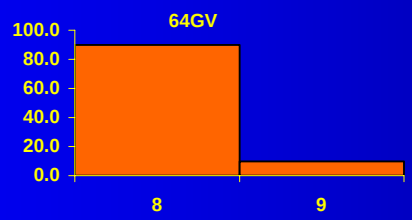


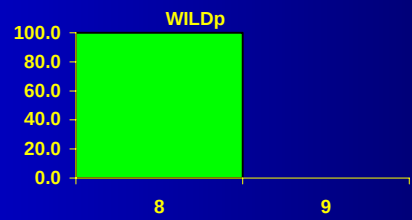


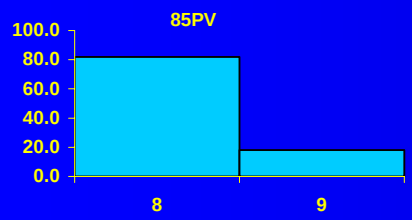


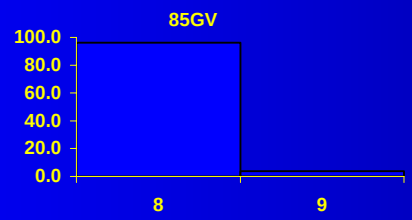
Lower Principal Caudal Rays	63PV	64GV	85PV	85GV	WILDp	WILDg
8	59.0	90.0	81.9	96.2	100.0	100.0
9	41.0	10.0	18.1	3.8	0.0	0.0

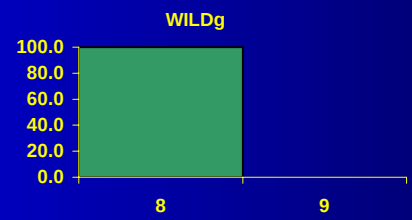




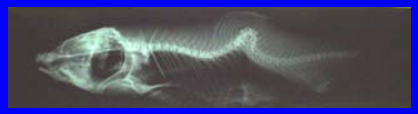


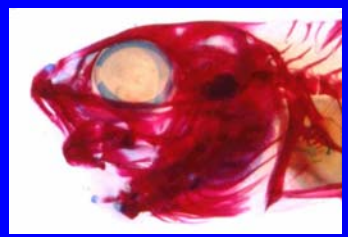






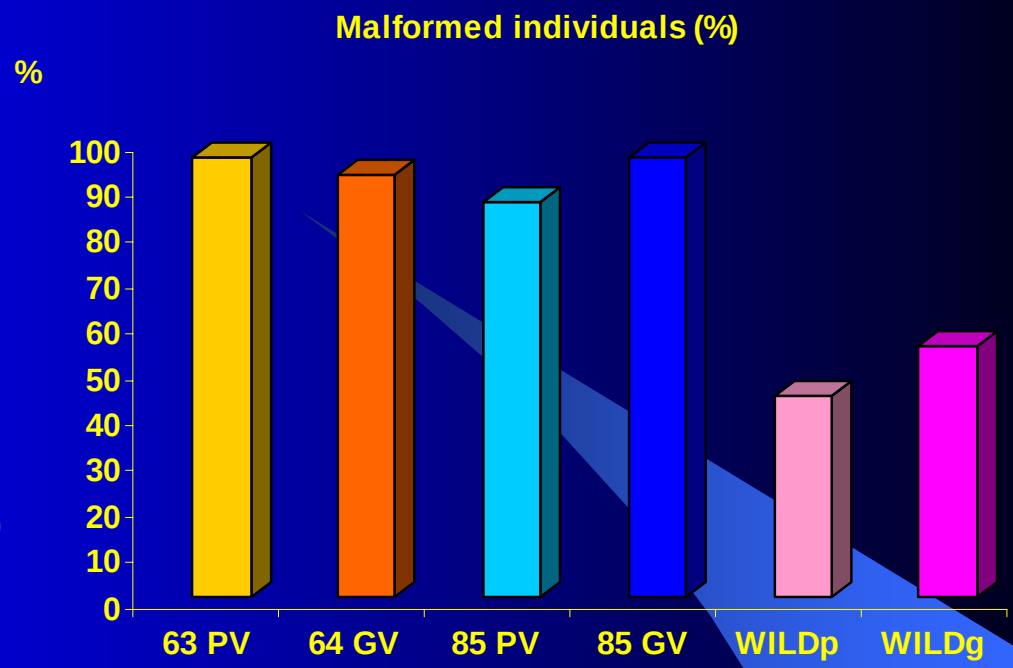
Skeletal anomalies

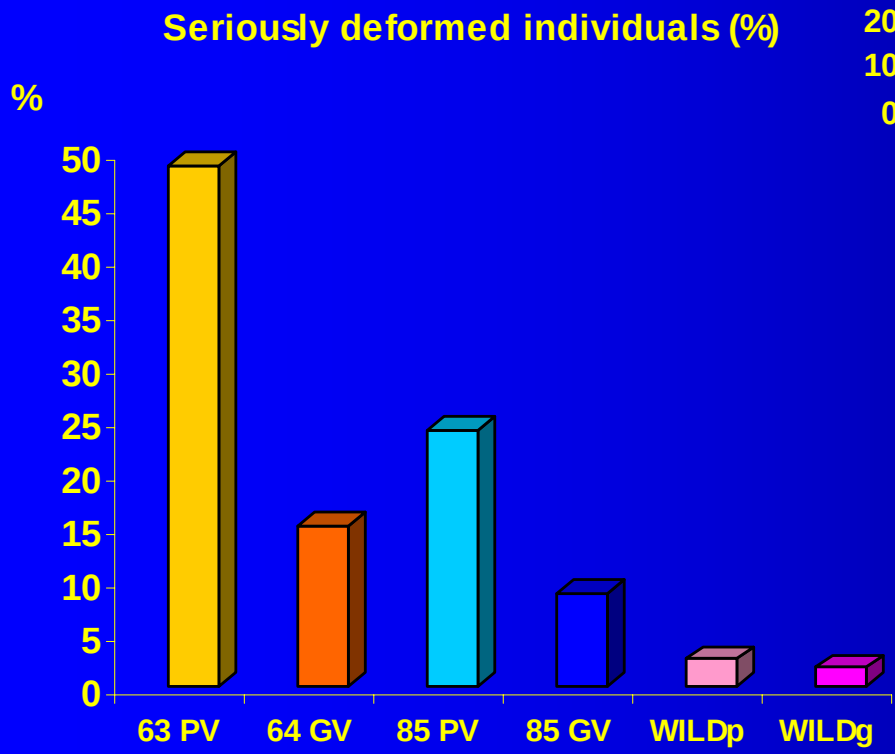




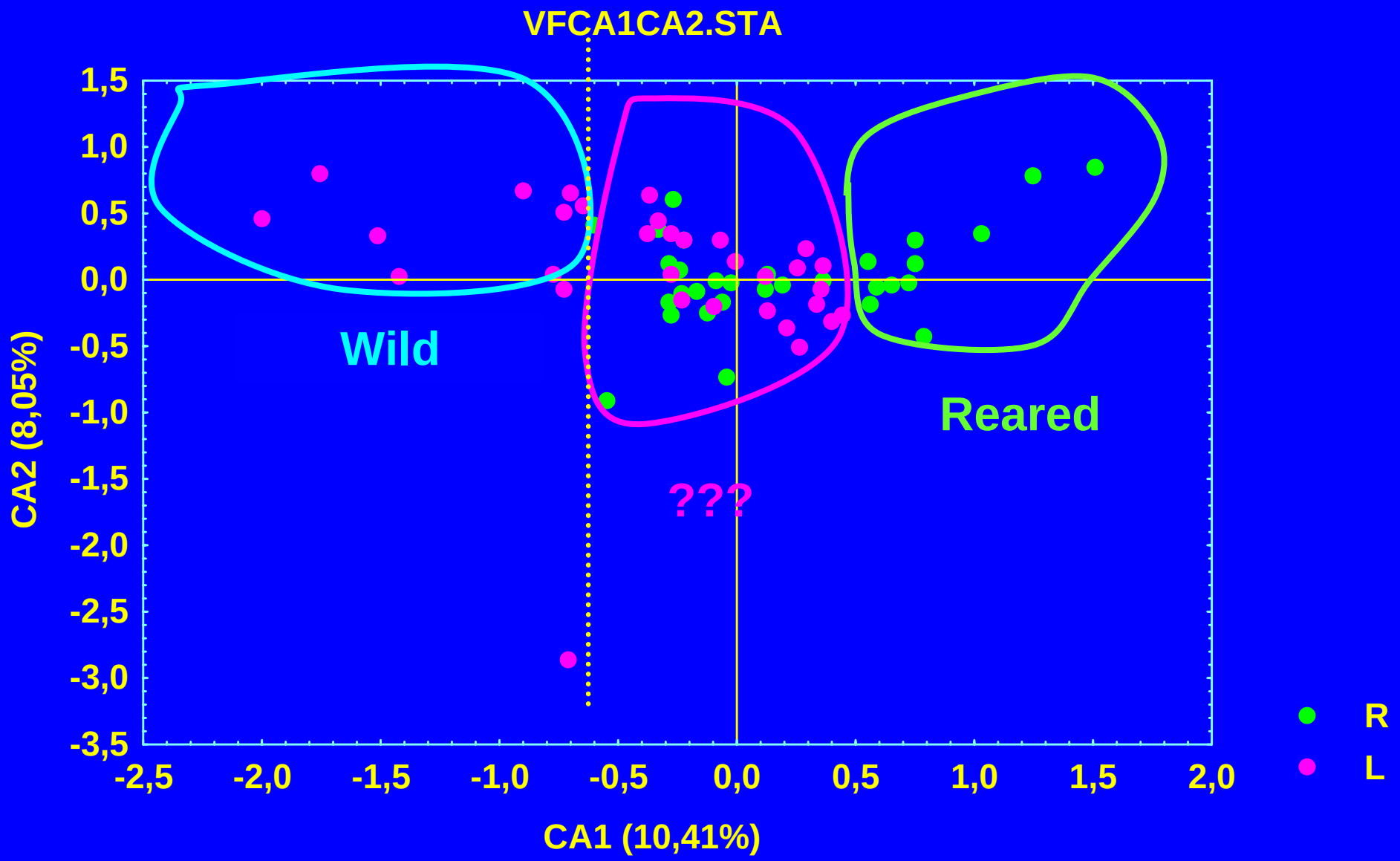
Region	A	Cephalic vertebrae (carrying epipleural ribs)
	B	Pre-hemal vertebrae (carrying epipleural and pleural ribs and with open hemal arch, without hemal spine)
	C	Hemal vertebrae (with hemal arch closed by a hemal spine)
	D	Caudal vertebrae (with hemal and neural arches closed by modified spines)
	E	Pectoral fin
	F	Anal fin
	G	Caudal fin
	H	Dorsal spines
	I	Dorsal soft rays
	S	Scoliosis
Type	1	Lordosis
	2	Kyphosis
	3	Vertebral fusion
	4	Malformed vertebral body
	5	Malformed neural arch and/or spine
	6	Malformed hemal arch and/or spine and/or rib
	7	Malformed ray (deformed, absent, fused, supenumerary)
	8	Malformed pterygophore (deformed, absent, fused, supenumerary)
	9	Malformed hypural (deformed, absent, fused, supenumerary)
	10	Malformed epural (deformed, absent, fused, supenumerary)
	12	Swim-bladder anomaly
	13	Presence of calculi in the terminal tract of the urinary ducts
	14	Prognatism of dental
	15	Reduced dental/Malformed pre-maxillary and/or maxillary
	16	Others
	17	Deformed or reduced opercle
	18	Deformed predorsal bone

Which of morphological criteria are good quality descriptors ?



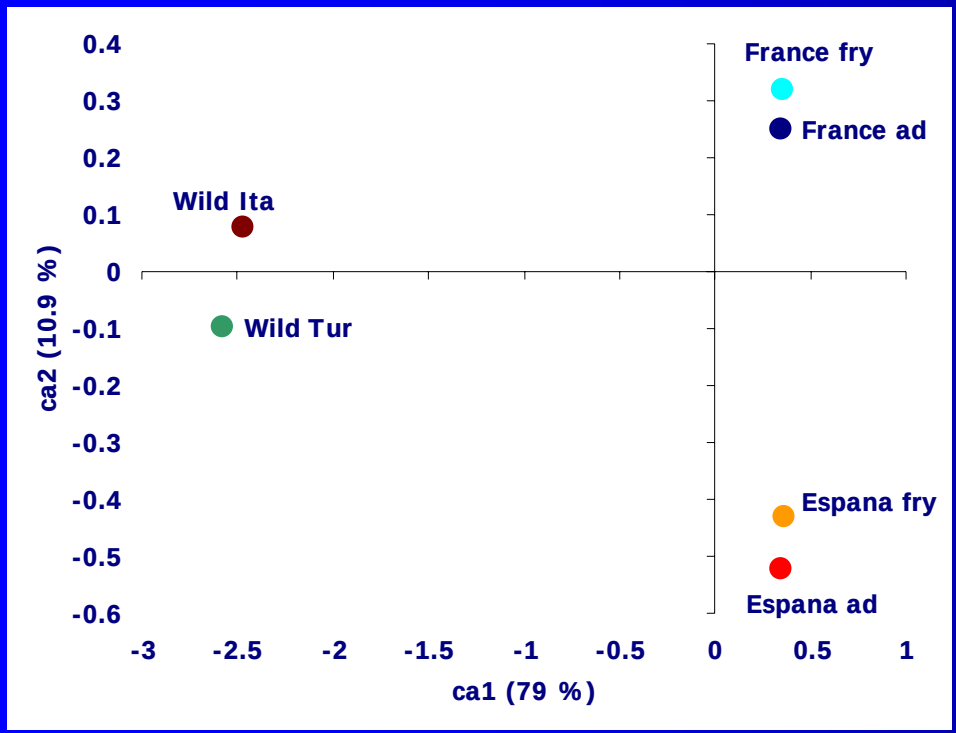


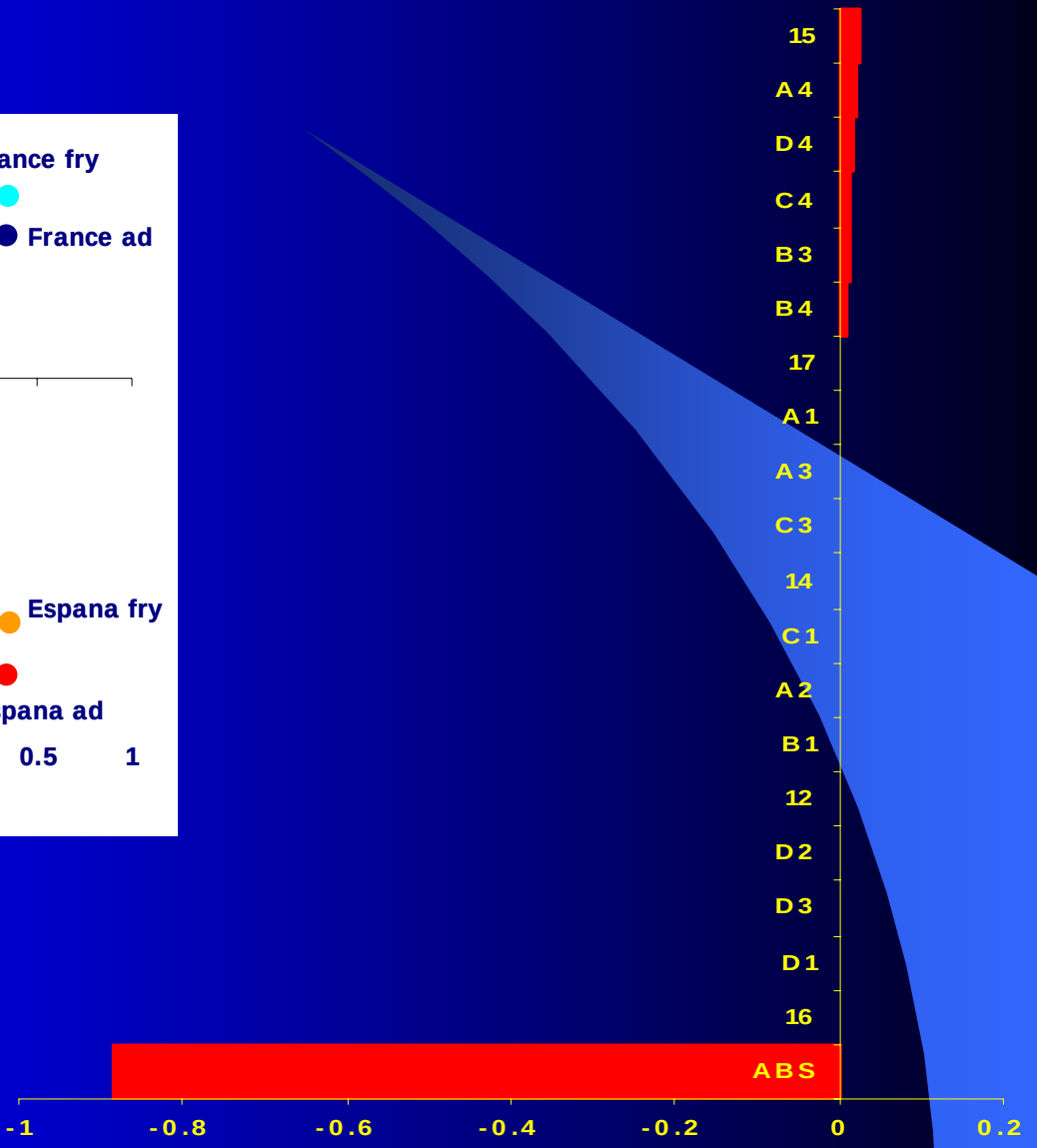
Have they predictive and discriminatory ability ?



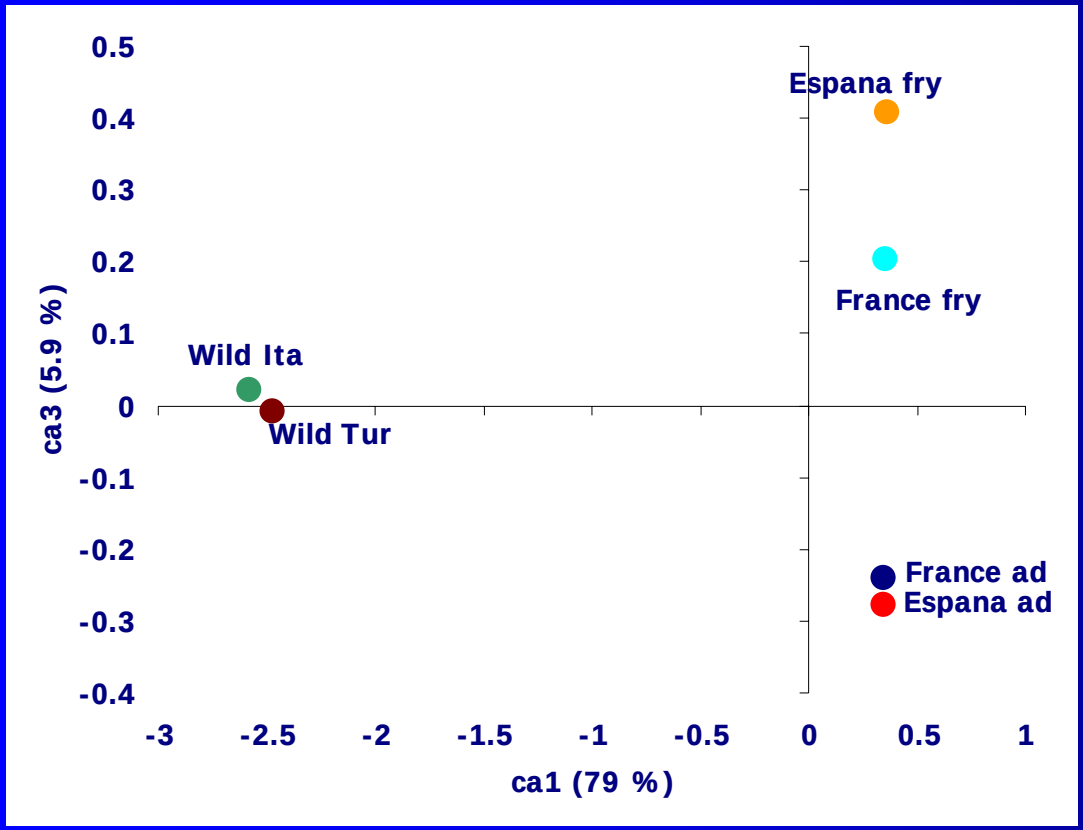
	CA1 (10,41%)	A4	A5	B2	B3	B4	B5	B7	C3	C4	C5	C6	D2	D4	D5	D6	F7	F8	G7	G9	G10	H7	H8	I7	I8	14	16	18	cs
L25	-2,00168	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L4	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L6	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L8	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L26	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L31	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L32	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L33	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L36	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L37	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L38	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L42	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L46	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L49	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L50	-1,76119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L30	-1,52118	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
L34	-1,42819	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L11	-0,90039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
L22	-0,90039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
L44	-0,77414	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
L19	-0,73433	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
L1	-0,73208	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L3	-0,73208	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
L20	-0,73208	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1
L7	-0,71622	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1
L43	-0,70834	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
L47	-0,65531	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
L27	-0,38334	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
L45	-0,38334	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
L13	-0,37295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
L2	-0,33786	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
L41	-0,28501	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1
L17	-0,28296	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
L5	-0,23968	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
L10	-0,22976	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
L18	-0,09792	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	1	0	1	0	0	0	1
L24	-0,07505	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	1
L39	-0,01284	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	1	0	0	1	1
L35	0,11732	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	1	1
L23	0,12133	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	1	0	0	1	0	1	0
L29	0,20289	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	0
L21	0,24795	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	1	0	1
L40	0,26278	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0
L14	0,28976	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	0
L48	0,33173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
L9	0,34528	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	1	0
L15	0,35841	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
L16	0,35841	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
L12	0,39106	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
L28	0,44135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0

Have they predictive ability ?

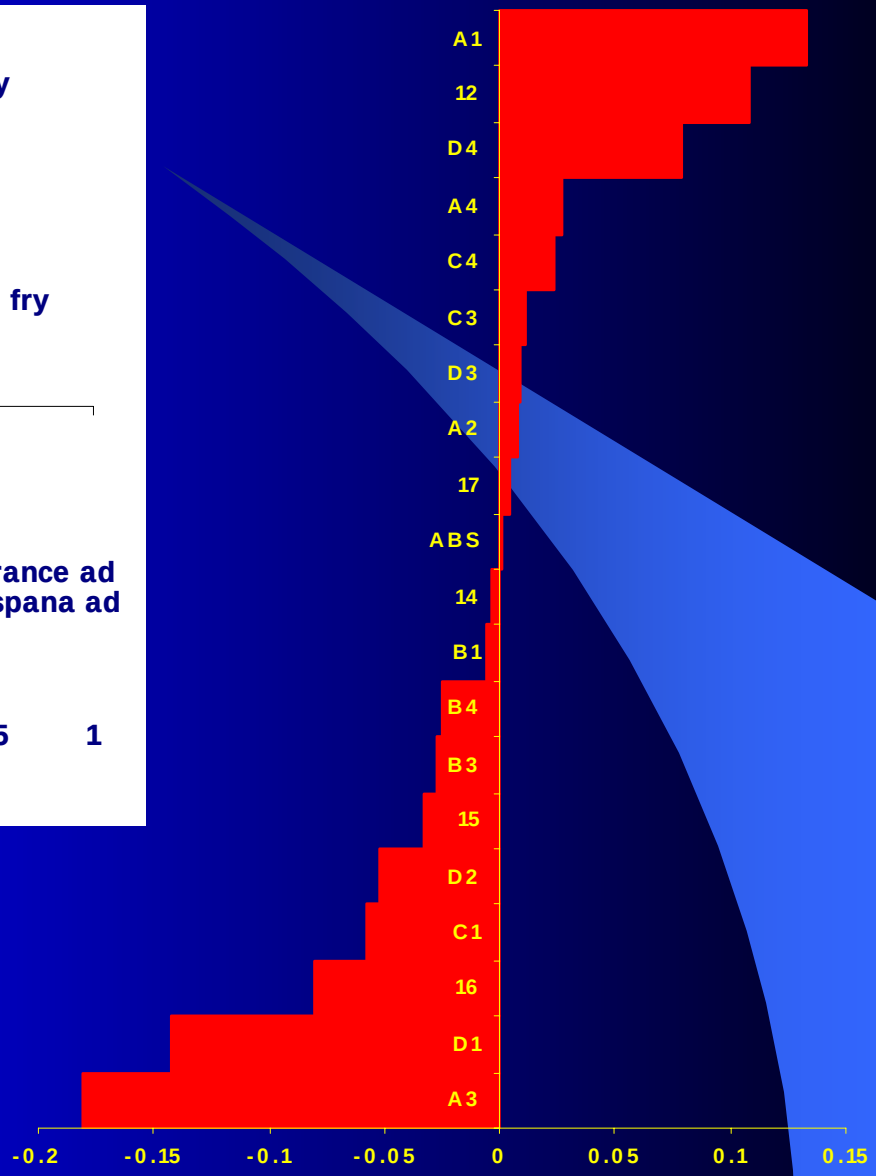




Have they predictive ability ?



ca3



What they 'describe' ?

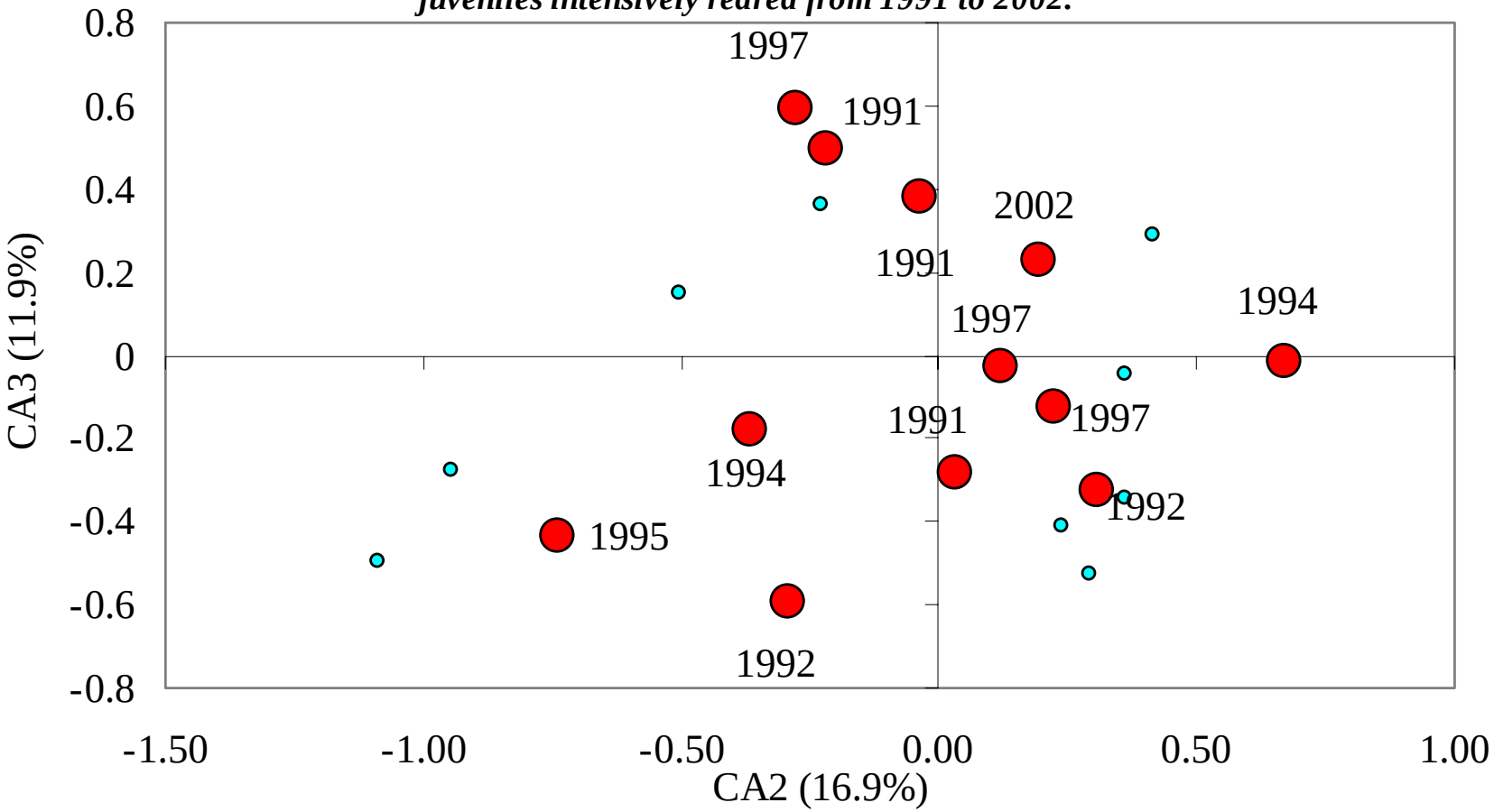
Sizing is a convenient practice?

Sparus aurata	VE2A (95d sz)	VE2B (VE2A siblings lz)	VD2 (ns)
Observed ind. (n)	128	220	263
Malformed ind. (n)	96	193	204
Malformed ind. (%)	75.0	87.7	77.6
Observed anom. types (n)	29	35	40
Observed anomalies (n)	269	556	580
Malformation charge	2.8	2.9	2.8
Severe anomalies (n)	47	87	84
Severe anom./tot. anom.	17.5	15.6	14.5
ind. with severe anom. (n)	37	69	63
ind. with severe anom. (%)	28.9	31.4	24
Severe anomalies charge	1.3	1.3	1.3

sz: small-sized group; ls: large-sized group; ns= not sized group

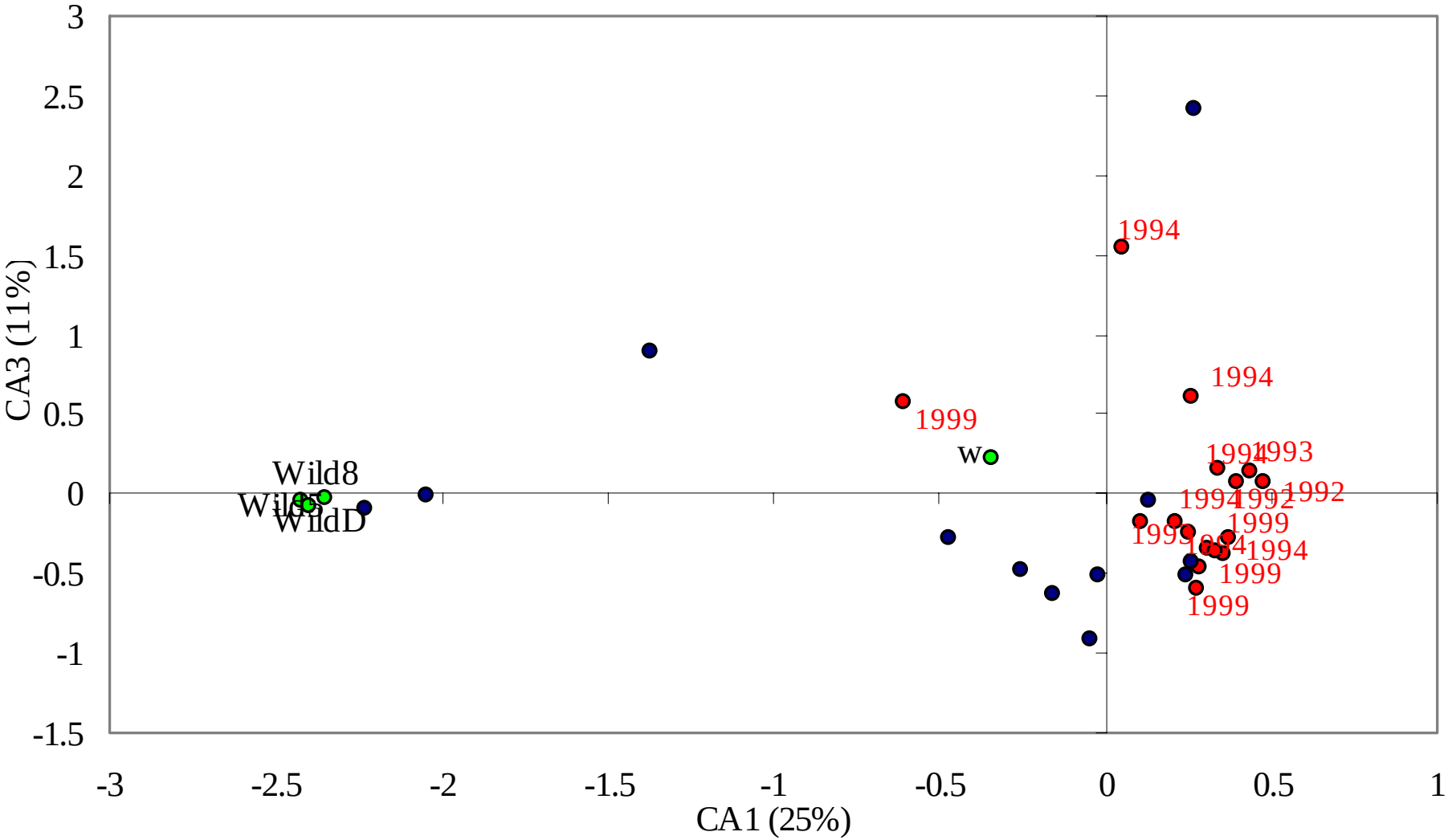
The quality of intensively reared fry is improving ?

Fig. 1: Correspondence Analysis: red dotsindicate batches of gilthead sea bream juveniles intensively reared from 1991 to 2002.



Quality

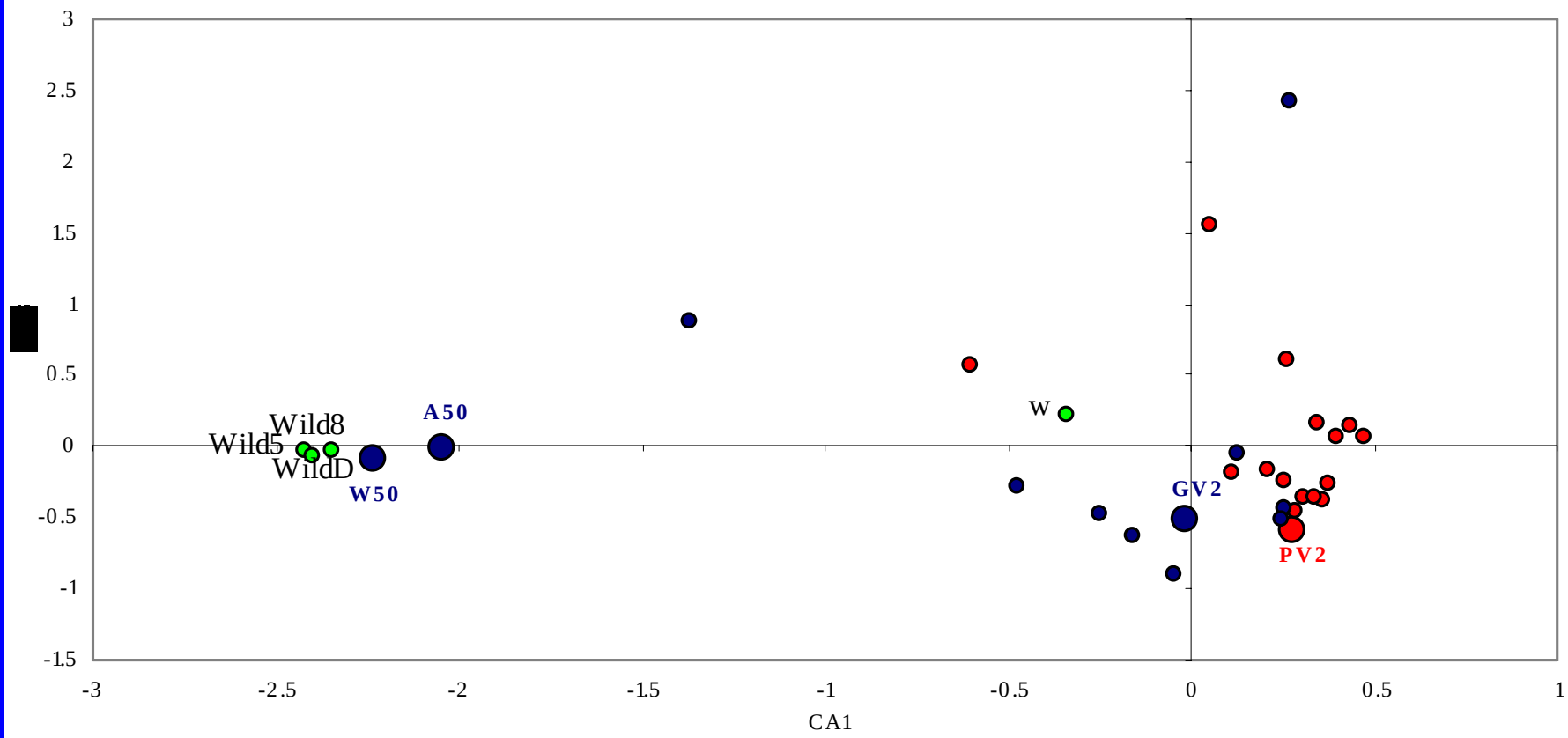
Fig. 2: Correspondence Analysis applied to sea bass batches.
red points: intensive; blue: Large Volume; red: wild



Quality

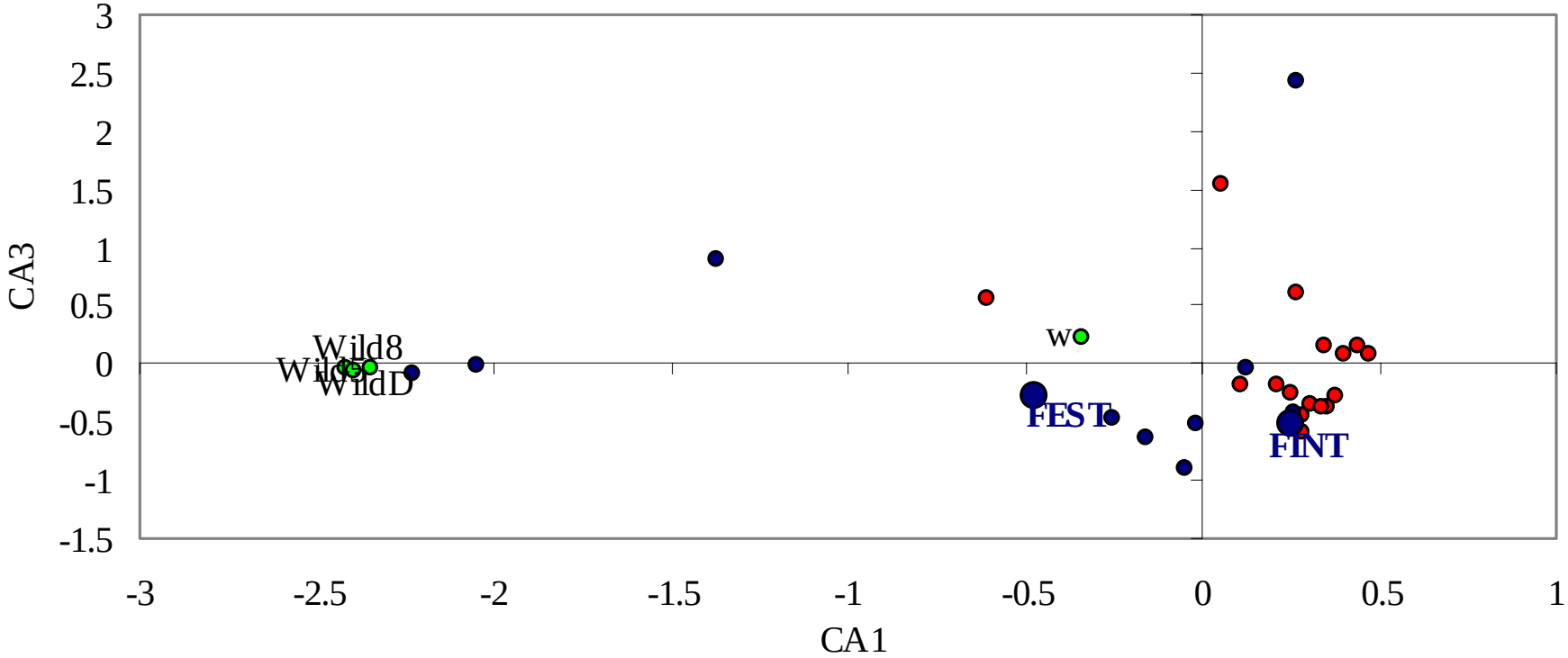
The quality of semi-intensively reared larvae is improving ?

Fig. 3: Correspondence Analysis applied to sea bass batches The batches GV2 and PV2 are siblings. Red: intensive; blue: Large Volume; green: wild



Quality

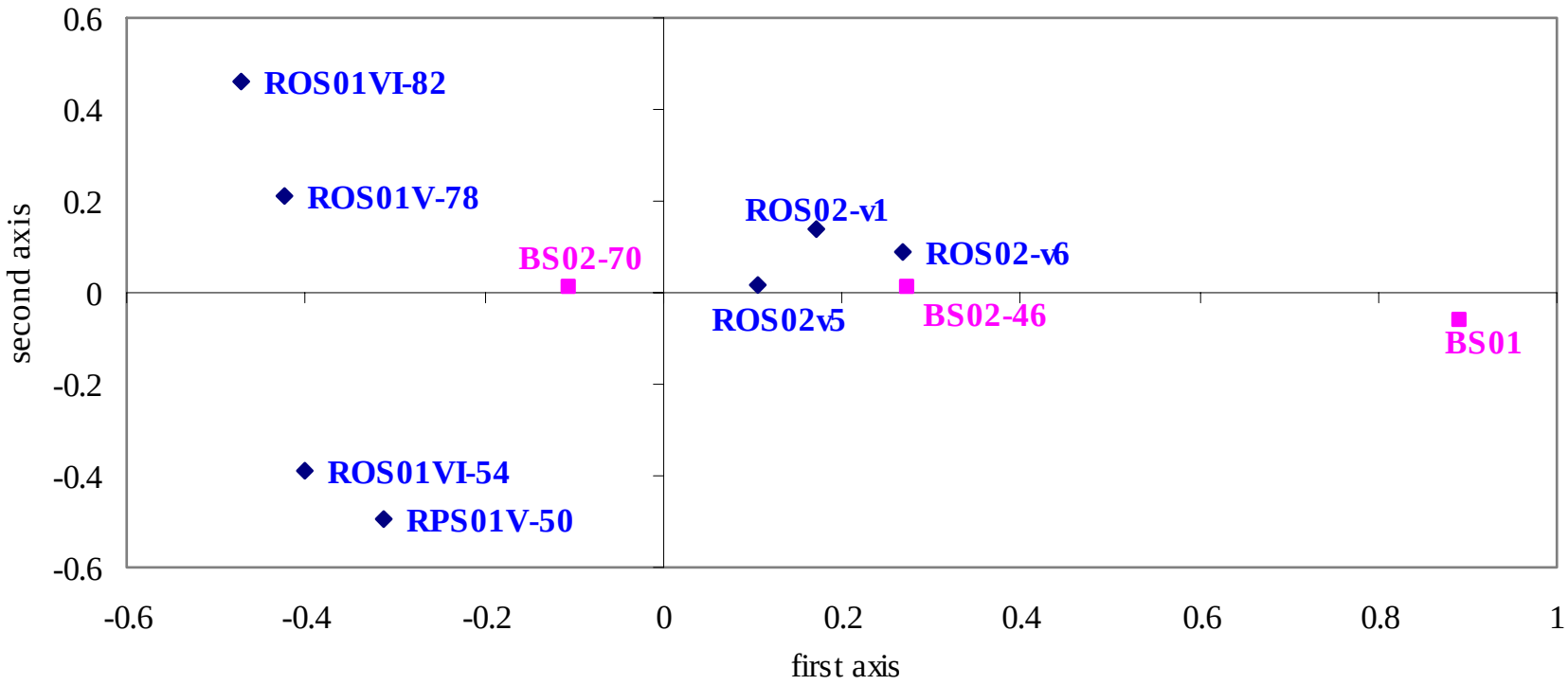
Fig. 4: Correspondence Analysis applied to sea bass batches. The batches GV2 and PV2 are siblings. Red: intensive; blue: Large Volume; green: wild



Quality

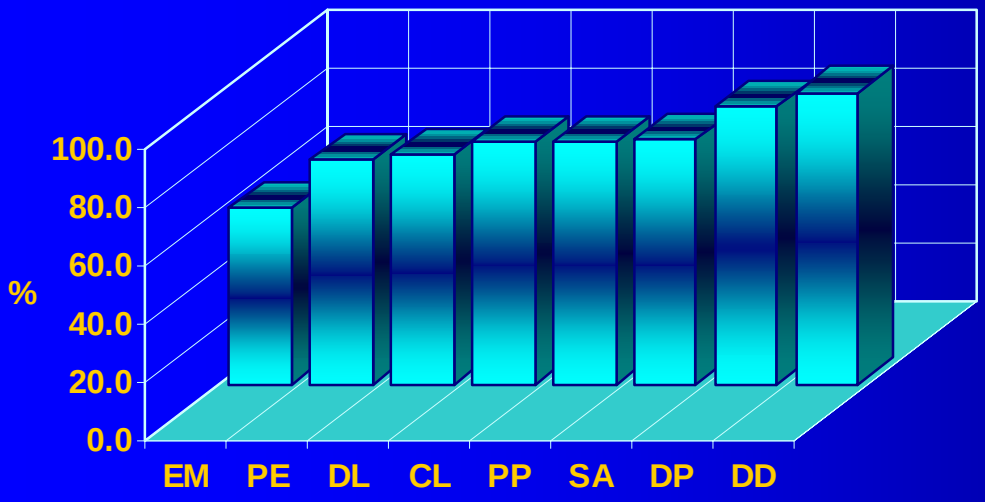
What about the quality of new species juveniles ?

Fig. 5: Principal Coordinate Analysis applied to dusky grouper juveniles. Blue point: 'green water'; pink: large volume; 01=2001 batches; 02=2002 batches.

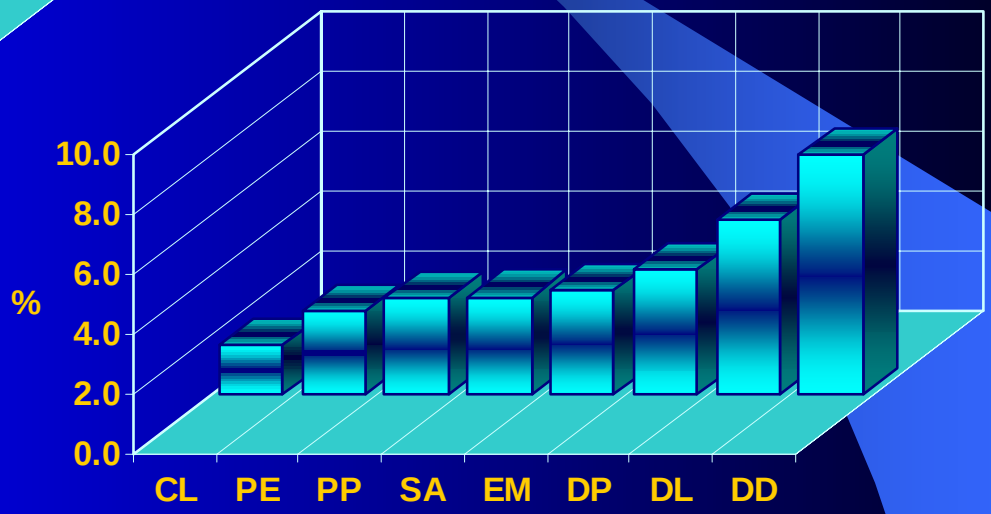


Quality

Malformed individuals (%)

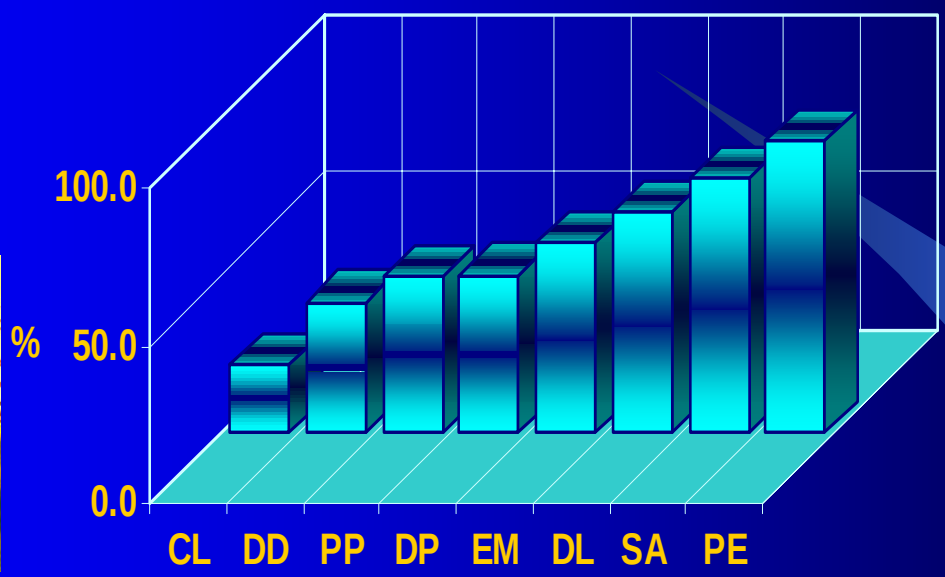


Malformation charge



CL: Thick lipped mullet (*Chelon labrosus*); PE: pandora (*Pagellus erythrinus*); PP: common seabream (*Pagrus pagrus*); SA: gilthead seabream (*Sparus aurata*); EM: dusky grouper (*Epinephelus marginatus*); DP: sharpsnout sea bream (*Diplodus puntazzo*); DL: sea bass (*Dicentrarchus labrax*); DD: common dentex (*Dentex dentex*).

Frequency of individuals with at least one severe anomalies



	gilthead sea bream [1]			sea bass [2]			dusky grouper [3]		
	MIN	MAX	AVER.	MIN	MAX	AVER.	MIN	MAX	AVER.
malformed individuals (%)	75.0	99.0	83.7	26.7	100.0	78.5	8.5	100.0	60.4
type of anomalies (n)	29	40	35	13	43	28	4	38	18
observed anomalies (n)	269	582	464	49	2075	605	5	639	167
malformation charge	2.8	5.3	3.3	2.0	16.6	5.9	1.3	7.0	3.5
severe anomalies (n)	47	87	67	9	394	108	1	80	31
severe anomalies/total observed anomalies	12.3	17.5	14.2	2.0	43.2	18.5	6.8	40.8	20.8
individuals with at least one severe anomaly (n)	37	69	50	5	131	42	1	46	20
individuals with at least one severe anomaly (%)	24.0	37.0	29.0	6.6	100.0	36.6	2.1	56.3	31.5
heavy anomalies charge	1.3	1.8	1.4	1.2	6.5	2.3	1.0	2.0	1.4

1= ON A TOTAL OF 913 INDIVIDUALS; 2 = 1,501; 3= 753.

GENERAL REMARKS

a. morphological criteria for fry quality criteria seem to be an excellent descriptor with predictive ability;
b. the main limits are the necessity to get many more information of experienced live of juveniles, larvae, eggs and breeders;
the narrow (scarce) availability of wild sampling (of the same age for morphometrics);
the necessity to not use 'experimental' environment (aquaria) to warrant an idoneous number of individual for sampling upper than the number of the possible skeletal anomalies (to reach some statistical significance, that is > +/- 70 individuals/sampling) and to have the 'control' lot (or what other could be the standard reference?) showing a rate of severely deformed individuals similar to wild's one;
c. the potentiality of such quality criteria can be ameliorated by achieving and incorporate in the data analysis of every data on what ever happened and who and how intervened at any rearing step.

RECOMMENDATION: use many and many fishes!