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# EARLY CRITERIA FOR THE SELECTION OF JUMPING ABILITY. H25-2

Horse commission (free communications)

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**Summary**

The aim of this study was to evaluate whether early measurements of morphology and gaits can be used to predict jumping performance.

Several hundred two 3 year-old French saddle horses participating in breeding events from 1998 to 2000 were tested for morphology and gaits. Their performance records in jumping were collected from 1999 to 2003. The Equimetrix™ gait analysis system provided 74 variables (10 for walking, 10 for trotting, 18 for free jumping and 36 for conformation) collected in 433horses for conformation, 255 for walking, 261 for trotting and 339 for free jumping. We report here a discriminant analysis of 125 horses measured for the 74 variables. Three categories were made according to the jumping competition results: (a) those horses having no earnings (b) those belonging to the 50% lower earnings and (c) those having 50% higher earnings.

The three categories could be discriminated with less than 3% of mistakes when using all the information on the 74 variables. First axis allowed isolating the (c) horses and second axis allowed separating (a) and (b) horses. However this result must not be over-weighted. The same analysis, on a stepwise mode, when introducing only significant variables lead to a mean canonical $R^2$ of 0.36 only, instead of 0.94 when all 74 variables were analysed. For the 14 significant variables then retained only 5 concerned conformation, the other variables concerned gaits (6) and free jumping (3).

For French saddle horses, predicting Jumping ability in competition by a conformation exam is illusory. The accuracy increases by measuring gaits and free jumping. However, even if the current examination could be improved its accuracy remains low. Therefore we do not think that it could replace the test of jumping aptitude in competition whose organisation has to be preserved when it exists or organised when it does not exist.

**Keywords:** horse; jumping; competition; conformation; gaits; free-jumping

## Introduction

It is a common practice in sport horse breeding to pre- select horses for training by an exterior examination of gaits and conformation. Sometime a free-jumping test is added. When in the past according to the variability of the population it was relatively easy to select saddle horses for military purposes out of coach-horse populations, this is now more difficult for sport horses because the variability of the candidates is greatly reduced. We have still shown how difficult it was to discriminate good and bad jumper according to their conformation (Langlois et.al. 1978). However, probably because of sociological reasons each breeder continue to believe that he is more skilled in this exam than the others generally qualified by him of none experts. The poor mean performance of this exam is then explained by few experts and a lot of none experts. We are here in a field of passion and subjectivity more relevant of human than of biological science (Langlois *et al.*1994 Langlois 2005). However, some researchers (Holmström et *al.*1990, 1994, 1995, Holmström and Philipsson (1993), Crevier et *al.* 2004, Métayer *et al.* 2004) are still exploring this kind of criteria, thinking that because selection on different performances lead to different type of horses something can be revealed by more accurate methods of measurements. Others, Back *et al.* (1994, 1995) Koenen *et al.* (1995), Wallin *et al.* (2003) have shown correlations between early tests on young horses and competition results. They also underlined the better prediction for dressage than for jumping. In the present study we propose to combine gait, jumping test and morphological measurements to predict the early jumping performance of saddle horses in competitions. The aim of this study was to evaluate whether early measurements of morphology and gaits can be used to predict jumping performance.

## Materials and methods

Horses and measurements

The morphological and gait measurements were performed in French breeding shows between 1998 and 2000. The horses were all 3-year-old during the tests. We check their performances in jumping competitions from 1999 to 2003. They were 4 to 7- year old. The morphological test was made by digital image analysis (Equimetrix™) and gait and jumping tests were made by accelerometric gait analysis system (Equimetrix™). For more details see Barrey and Galloux (1997) Barrey *et al.* (2002) Biau and Barrey (2004). The three tests provided a total of 74 variables:

- 10 for walking and 10 for trotting. See table1 for their definitions and table2 for simple statistics.
- 18 for free-jumping. See table 3 for definition and table 4 for simple statistics.
- 36 for conformation. See table5 for definition and table 6 for simple statistics.

These variables were collected in 433 horses for conformation, 255 for walking, 261 for trotting and 339 for free-jumping. We report here only for a discriminant analysis of 125 horses measured for the 74 variables.

Three categories were made according to the jumping competition result:

- (a) those 36 horses having no earnings
- (b) those 30 belonging to the 50% lower earnings
- (c) those 59, having 50% higher earnings.

In fact, the best annual earnings index (ISO indice Saut d'Obstacles) according to Langlois et al. (2004) was used to make the repartition: (a) = no index; (b) ISO<= 100; (c) ISO> 100.

Discriminant analyses were implemented using PROCDISCRIM or STEPDISC from the SAS software. The first one is adjusting the best discriminant functions on the data (two for three groups) whatever the differences observed between groups are significant or not. The second one is using only significant differences to run the discrimination. It may loss some useful information but its performance in the classification of future observations should be better evaluated. Indeed, the same data set can be used both to define and to evaluate the classification criteria. The resulting error count (misclassifications) estimate has an optimistic bias and is called apparent error rate.

Cross validation was proposed to reduce this bias. Cross validation treats n-1 out of n training observations as a training set. It determines the discriminant functions based on these n-1 observations and then applies them to classify the one observation left out. This is done for each of the n training observations. The misclassification rate for each group is the proportion of sample observations in that group that are misclassified. This results in the cross validation error-rates estimates which we calculate in every case.

## Results

The discriminant analysis on the 74 variables available for 125 horses allowed the definition of two canonical variables or axis explaining the quasi totality of the variation between the three groups (average square canonical correlation of 0.94). As shown by figure1 Axis 1 allowed to separate c horses (the best ones) from the (a+b) horses and Axis 2 allowed to separate (a) horses (unplaced ones) from (b+c) horses. More detailed results are given Table 7. One can remark how good we can adjust the data with an apparent error count estimate of only 3%. However this adjustment falls dramatically to 45.4% of misclassifications when a crossvalidation procedure is used.

The results with priors proportional diminishes the total apparent error count to 1.6% and the crossvalidation error rate to 44.8% that is by near one percent.

When a stepwise analysis is used, only variables with a significance level to enter or to stay of 0.15 are introduced in the calculations. From the 74 variables only14 stayed. They were available for 172 horses. These are for walking: step length (Lf), regularity (reg), vertical displacement (depla_v), percent of four beats steps (temps), mean propulsion effort (vpro) and the same variable for trotting (tvpro).

For conformation:sternal height (Videsste), length of posterior canon bone (phalangp), hip angle (ahanche) hock angle (ajarret),deep of back to top of hip distance (dosarr).

For free-jumping: total pusching effort relative to the reception effort (totalr), taking off duration (dappel), horizontal component of effort during taking off (pousl).

As shown by figure 2 the two first axis did not allow a so good adjustment as previously. In fact the average square canonical correlation is now of only 0.36. and the apparent error rate (Table 8) is of 41% and grew up to 51% with the crossvalidation procedure. The results with priors proportional diminishes the total apparent error count to 40.1% and the Crossvalidation error count to 50.6%, that is by near one percent again.

## discussion

Crossvalidation misclassification error count with an error rate between 45 and 51% whatever the priors (equal/proportional) or the method (all variables/stepwise selected variables) indicate that it is very difficult to allocate one horse to one of the three groups despite the very good adjustment we can get using all the 74 variables leading to an apparent error rate smaller than 3%. This result is a very good illustration of the fact that adjustment of the data and prediction must not be confounded.

However, one can remark that there is a continuity between group b and c, that render the allocation more difficult. To check this objection we conducted the same discriminant analyses (full results not given) between category a and pooled categories b and c. Crossvalidation error rate is then in the range 34-42%. It is less than before but still high and nothing about the quality of the horse is inferred. To do that, knowing that a horse will earn, the prediction of his best earning index by a multiple regression reach a $R^2$ of 51% at most and 34% at least. This is not too bad because ii represent a correlation of 0.7 in the first case and 0.6 in the second. It therefore appears that the main limiting factor is to predict whether the horse will earn or not which has still a great error rate.

From this complementary analysis we can conclude that the first results on the three groups can be improved only slightly when considering two groups and continuity in the quality of earning horses. We limit us therefore to the statement of the three group analyses.

## Conclusion

For French saddle horses, predicting jumping ability in competition by a conformation exam is illusory. The accuracy can be improved by measuring gaits and free jumping, but the accuracy of the prediction remains low. Therefore we do not think that the current examination of 3-year-old in breeding shows could replace the test of jumping aptitude in competition whose organisation has to be preserved when it exist or organised when it does not exist. This is particularly true for the selection of stallions and mares for the production of "Selle-Français" where the traditional requirements based on 3-year-old horse shows are totally out of fashion for the selection of jumping aptitude, the most important character in our country.

## Manufacturers' addresses

Equimetrix$^{TM}$ distributed by Centaure Metrix, 6, rue Marrier 77 300 Fontainebleau, France

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Table1: Definitions of the walk and trot variables

| | | |
|---|---|---|
| | | **STRIDE** |
| VITESSE | *m/s* | Speed |
| LF | *m/s* | Stride length |
| FF | *cycles/s or Hz* | Stride frequency |
| | | **VERTICAL MOVEMENTS** |
| SYM | *%* | Stride symmetry |
| REG | */200* | Stride regularity |
| DEPLA-V | m | Dorsoventral displacement |
| EAPPUI | W/Kg | Dorsoventral activity |
| TEMPS | % | Percent of 4 beat strides by walking and, 2 beat strides by trotting |
| | | **PROPULSION** |
| VPRO | g | mean propulsion force |
| DPRO | % | propulsion duration |
| EPRO | W/Kg | longitudinal activity |

Table 2: Simple statistics for the variables for gaits in hand

| | | *WALKING* | | *TROTTING* | |
|---|---|---|---|---|---|
| | *Units* | *Mean* | *Std-dev.* | *Mean* | *Std-dev.* |
| ***Stride*** | | | | | |
| *VITESSE* | *m/s* | *1.7* | *0.13* | *4.03* | *O.56* |
| *LF* | *m/s* | *1.9* | *0.14* | *2.9* | *0.33* |
| *FF* | *cyclus/s ou Hz* | *0.9* | *0.06* | *1.4* | *0.08* |
| ***Vertical movements*** | | | | | |
| *SYM* | *%* | *90.6* | *7.57* | *97.2* | *3O.* |
| *SYMTZ* | */400* | *167.4* | *47.8* | *231.2* | *47.3* |
| *REG* | */200* | *144.3* | *20.8* | *184.0* | *8.4* |
| *REGTZ* | */450* | *189.7* | *43.5* | *329.2* | *44.9* |
| *DEPLV* | *m* | *O.O4* | *0.01* | *0.10* | *0.02* |
| *EAPPUI* | *W/kg* | *1.2* | *0.58* | *23.4* | *6.90* |
| *TEMPS* | *%* | *36.4* | *13.9* | *90.5* | *3.8* |
| ***propulsion*** | | | | | |
| *VPRO* | *g* | *6.5* | *2.5* | *9.0* | *2.5* |
| *DPRO* | *%* | *28.8* | *5.6* | *30.0* | *5.1* |
| *EPRO* | *W/kg* | *0.48* | *0.31* | *2.O3* | *0.95* |

Table3: Definitions of the variables for free-jumping

| | | units |
|---|---|---|
| **Coming on = quality of the gallop before the jump** | | |
| SFF | Stride frequency | Hz |
| EPSDV | Dorsoventral activity | W/kg |
| EPSDH | Longitudinal activity | W/kg |
| **Take-off = quality of the effort** | | |
| ANT | Push of the fore limb | g |
| ANTR | Push of the fore limb / total effort at take-off | % |
| POST | Push of the hind limb | g |
| POSTR | Push of the hind limb / total effort at take-off | % |
| TOTAL | Total effort at take-off | g |
| TOTALR | Total effort at take-off /effort at landing | Without dim. |
| POUSL | Horizontal decomposition of the push of the hind limbs | g |
| POUSV | Vertical decomposition of the push of the hind limbs | g |
| RATIO | Ratio push of the fore limb / push of the hind limb | Without dim. |
| DIFAP | Difference between the push of the fore limb and hind limb | g |
| RSAUT | correlation with the reference jump | Without dim. |
| DAPPEL | Take-off duration | sec |
| **Jump** | | |
| DSAUT | Duration of the jump | sec |
| HSAUT | Vertical displacement during the jump | m |
| **Landing** | | |
| RECEP | Maximal effort of the fore limb at landing | g |

Table4: Simple statistics for the variables for free-jumping

MEANS OF THE VARIABLES FOR FREE JUMPING

| **Abbréviation** | **units** | **number** | **Mean** | **Std-dev.** | **mini** | **maxi** |
|---|---|---|---|---|---|---|
| **Coming on** | | | | | | |
| FF OU SFF | cyclus/s, Hz | 339 | 1.84 | 0.16 | 0.88 | 2;15 |
| EPSDV | W/kg | 339 | 27.9 | 5.4 | 16.6 | 43.9 |
| EPSDH | W/kg | 323 | 6.8 | 2.6 | 2.2 | 18.0 |
| **Take off** | | | | | | |
| ANT | g | 339 | 2.9 | 0.5 | 1.8 | 4.7 |
| ANTR | % | 306 | 74.5 | 13.5 | 46.0 | 136.6 |
| POST | g | 339 | 1.8 | 0.6 | 0.6 | 5.1 |
| POSTR | % | 306 | 44.9 | 15.0 | 12.9 | 117.4 |
| TOTAL | g | 338 | 4.7 | 0.7 | 3.0 | 7.6 |
| TOTALR | without dim | 339 | 1.20 | 0.2 | 0.66 | 2.05 |
| POUSL=HPOST | g | 313 | 0.90 | 0.65 | 0.07(-) | 5.06 |
| POUSV | g | 306 | 2.05 | 0.68 | 0.89 | 5.14 |
| RATIO | without dim | 339 | 2.48 | 5.O8 | 33.7(-) | 60.0 |
| DIFAP | g | 306 | 1.19 | 0.74 | 2.57(-) | 3.08 |
| RSAUT | without dim | 339 | 6.5 | 21.1 | 0.66 | 94.4 |
| DAPPEL | sec | 339 | 0.31 | 0.06 | 0.17 | 0.46 |
| **Jump** | | | | | | |
| DSAUT | sec | 339 | 0.28 | 0.08 | 0.04 | 0.55 |
| HSAUT | m | 170 | 0.37 | 0.07 | 0.24 | 0.56 |
| **Landing** | | | | | | |
| RECEP | g | 339 | 4.05 | 0.59 | 2.6 | 6.0 |

Table5: Definitions of the variables for morphology.

| | |
|---|---|
| **Height** | |
| TAILLE_G | wither height |
| TAILLE_C | croup height |
| VIDESSTE | sternum height |
| THORAX | depth of chest |
| **Top line** | |
| TETE | Head length |
| ENCOLURE | neck length |
| LONGUEUR | body length from sternum to thigh |
| **Back** | |
| DOSAV | Length from the deep of the back to the summit of the withers |
| DOSARR | Length from the deep of the back to the summit of the croup |
| ADOS | angle made by the summit of the wither with the summit of the croup from the deep of the back |
| IGARROT | Obliquity of the line deep of the back-summit of the withers with the horizontal line. |
| **Hind limbs - segments** | |
| COXAE | Length from the hip apex to the coxo-fémoral joint |
| SACRE | Length from the summit of the croup to the coxo-fémoral joint |
| FEMUR | Length of the femur |
| TIBIA | Length of the tibia |
| METATARS | Length of the hind limb canon bone |
| PHALANGP | Length of the hind limb pastern |
| **Hind limbs-angles and obliquities** | |
| IBASSIN | Obliquity of the pelvis/horizontal |
| IFEMUR | Obliquity of the femur/horizontal |
| AHANCHE | angle pelvis-femur |
| AGRASSET | Stiffle angle |
| AJARRET | Hock angle |
| **Fore limbs - segments** | |
| SCAPULA | Length of the shoulder |
| HUMERUS | Length of the fore-arm |
| RADIUS | Length of the arm |
| METACARP | Length of the fore limb canon bone |
| PHALANGA | Length of the fore limb pastern |
| **Fore limbs angles and obliquities** | |
| IEPAULE | Obliquity of the shoulder |
| AEPAULE | angle scapula-humerus |
| ACOUDE | Angle of the elbow (humerus-radius) |

Units: Lengths in meters and angles in degrees

Table6: Simple statistics for the variables for conformation

| MEAN OF THE VARIABLES OF CONFORMATION | units | Number | Mean | Std-dev. | mini | maxi |
|---|---|---|---|---|---|---|
| **Height** | | | | | | |
| TAILLE_G | m | 433 | 1.66 | 0.O5 | 1.50 | 1.80 |
| TAILLE_C | m | 433 | 1.65 | 0.O5 | 1.48 | 1.81 |
| VIDESSTE | m | 433 | 0.87 | 0.O3 | 0.77 | 0.98 |
| THORAX | m | 433 | 0.78 | 0.03 | 0.66 | 0.88 |
| **Top line** | | | | | | |
| TETE | m | 433 | 0.52 | 0.04 | 0.39 | 0.60 |
| ENCOLURE | m | 433 | 0.79 | 0.07 | 0.54 | 1.17 |
| LONGUEUR | m | 433 | 1.48 | 0.06 | 1.26 | 1.68 |
| DOSAV | m | 433 | 0.29 | 0.04 | 0.20 | 0.41 |
| DOSARR | m | 433 | 0.59 | 0.05 | 0.46 | 0.72 |
| ADOS | deg | 433 | 154.2 | 2.9 | 145.0 | 165.0 |
| IGARROT | deg | 433 | 17.5 | 3.0 | 8.0 | 28.0 |
| **Hind limbs- segments** | | | | | | |
| COXAE | m | 433 | 0.39 | 0.04 | 0.25 | 0.49 |
| SACRE | m | 433 | 0.36 | 0.03 | 0.26 | 0.44 |
| FEMUR | m | 433 | 0.45 | O.O3 | 0.35 | O.56 |
| TIBIA | m | 433 | 0.51 | O.O4 | 0.35 | 0.61 |
| METATARS | m | 433 | 0.38 | O.O2 | 0.30 | 0.45 |
| PHALANGP | m | 433 | 0.27 | 0.02 | O.22 | O.32 |
| **Hind limbs-angles and obliquities** | | | | | | |
| IBASSIN | deg | 433 | 20.50 | 4.8 | 9.0 | 36.0 |
| IFEMUR | deg | 433 | 63.8 | 5.4 | 50.0 | 93.0 |
| AHANCHE | deg | 433 | 84.2 | 7.3 | 66.0 | 120.0 |
| AGRASSET | deg | 433 | 121.4 | 6.4 | 105.0 | 161.0 |
| AJARRET | deg | 433 | 156.7 | 3.8 | 142.0 | 168.0 |
| **Front Limbs-segments** | | | | | | |
| SCAPULA | m | 433 | 0.50 | 0.04 | 0.41 | 0.61 |
| HUMERUS | m | 433 | 0.31 | 0.02 | 0.25 | 0.39 |
| RADIUS | m | 433 | 0.43 | 0.03 | 0.36 | 0.49 |
| METACARP | m | 433 | 0.29 | 0.02 | 0.24 | 0.36 |
| PHALANGA | m | 433 | 0.27 | 0.02 | 0.23 | 0.33 |
| **Front Limbs-angles and obliquities** | | | | | | |
| IEPAULE | deg | 433 | 57.66 | 4.8 | 47.0 | 70.0 |
| AEPAULE | deg | 433 | 110.1 | 10.3 | 91.0 | 131.0 |
| ACOUDE | deg | 433 | 145.6 | 7.4 | 121.0 | 162.0 |

Table 7 Summary of the discriminant analysis on 125 horses measured for 74 variables

| | Eigen value | Proportion | Square canonical correlation $R^2$ | Signification |
|---|---|---|---|---|
| 1 | 4.12 | 0.64 | 0.80 | *** |
| 2 | 2.35 | 0.36 | 0.70 | * |
| | $D^2$ generalized square distance | | | |
| | a | b | c | |
| a | 0 | 18.34 | 17.45 | |
| b | | 0 | 23.67 | |
| c | | | 0 | |
| | Apparent and **cross-validation** misclassification count | | | |
| | Number of observations classified into | | | |
| from | a | b | c | total |
| a | 34 | 1 | 1 | 36 |
| | **16** | **10** | **10** | |
| b | 0 | 30 | 0 | 30 |
| | **8** | **17** | **5** | |
| c | 2 | 0 | 57 | 59 |
| | **13** | **9** | **37** | |
| total | 36 | 31 | 58 | 125 |
| | **37** | **36** | **52** | |
| Priors | 0.33 | 0.33 | 0.33 | |
| | Error rate estimates | | | |
| Apparent | 0.056 | 0.000 | 0.034 | 0.030 |
| **Cross-validation** | **0.596** | **0.433** | **0.373** | **0.454** |

Figure1 Repartition of the observations according to the two axes
(All the74 variables kept in the discriminant function whatever their significance)

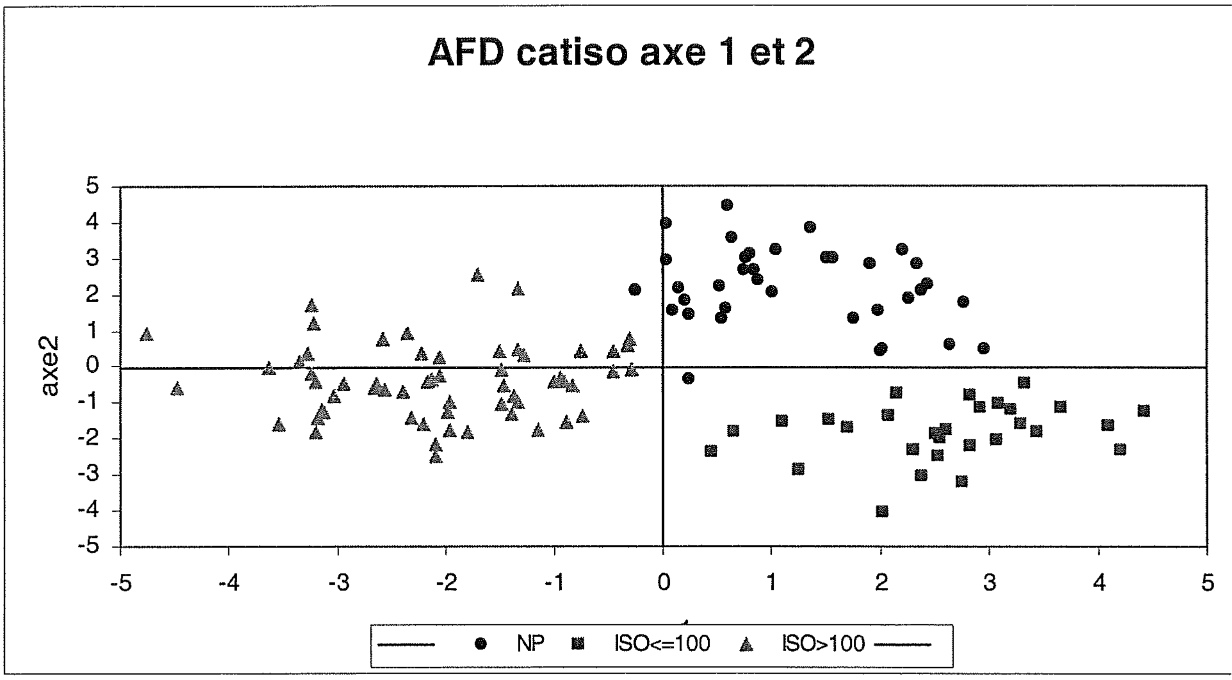

Table 8 Summary of the discriminant analysis on 172 horses measured for 14 variables significantly discriminant

| | Eigen value | Proportion | Square canonical correlation $R^2$ | Signification |
|---|---|---|---|---|
| 1 | 0.273 | 0.58 | 0.21 | *** |
| 2 | 0.197 | 0.49 | 0.16 | ** |
| | $D^2$ generalized square distance | | | |
| | a | b | c | |
| a | 0 | 1.58 | 1.57 | |
| b | | 0 | 1.13 | |
| c | | | 0 | |
| | Apparent and **crossvalidation** misclassification count | | | |
| | Number of observations classified into | | | |
| from | a | b | c | total |
| a | 32 | 8 | 9 | 49 |
| | **27** | **11** | **11** | |
| b | 9 | 28 | 15 | 52 |
| | **12** | **20** | **20** | |
| c | 13 | 17 | 41 | 71 |
| | **15** | **18** | **38** | |
| total | 54 | 53 | 65 | 172 |
| | **54** | **49** | **69** | |
| Priors | 0.33 | 0.33 | 0.33 | |
| | Error rate estimates | | | |
| Apparent | 0.347 | 0.462 | 0.422 | 0.410 |
| **Crossvalidation** | **0.449** | **0.615** | **0.465** | **0.510** |

Figure 2 Repartition of the data according to the two axes
(Stepwise procedure, 14 variables kept in the discriminant functions)