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A quantitive approach to an ecological study for scientific learning in the lower secondary school

ABSTRACT

The author reports the results of a study conducted on a third-year middle class aimed to impact evaluating on basic mathematical and scientific knowledge learning of a teaching experience based on campaign research methodology. Students were prepared and evaluated on theoretical and practical aspects of fish fauna quantitative ecological analysis of two Astian Monferrato's watercourses (Piedmont, Nothern Italy). Among educational conclusions, the need to broaden the disciplinary statistics knowledge in lower secondary school's programs and a lesser characterized didactic action of usually proposed experiences's formal and technical contents.

Keywords: Coleoptera, Staphylinidae, Xantholinini, new species, *Thyreocephalus*, *Metocinus*, *Byziniella*, *Chaetocinus*, Kenya.

INTRODUCTION

Work involved a third class (15 students) of Cocconato d'Asti state secondary school (Astian Monferrato, Piedmont, Nothern Italy) in the 2003/2004 school year. Project's premise was related to awareness spread among future adults of basin surface running waters' manage in a rational way in order to ensure an adequate protection, through scientific skills enhancement acquired during lower middle school. Biological *resources* are deserving of particular attention both because they are linked to fishing activities and because they are a level's ecological quality reliable signal. Fish fauna is the most relevant among water resources, both for activities related to professional or amateur fishing, and for the key role as an indicator of environmental health state and indirectly of possibilities use for human purposes (potable, irrigation, industrial, recreational).

River ecosystem components therefore require conservation and management methods appropriate to their status as a "resource" in all respects, therefore based on rational and scientifically supported bases against a context of mutually compatible multiple uses. Such intentions have risked and are still at risk of remaining without operational translation due to serious knowledge gaps about qualitative and quantitative ichthyocenosis characteristics, which constitute cognitive supports'structural elements as any management policy's essential premise. Ichthyological studies' development will make

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it possible to identify the possible correlations and functional relationships to reliable parameters' identification drawing ichthyocenosis and their relations with environmental variables, minimizing subjectivity's inevitable component, decisive in the experimental phase, as dependent directly on operator's sensitivity, preparation and experience. These considerations, exposed to students, contributed to motivate present work's meaning, aimed to identifying, in two hilly watercourse stations, quantitative composition of cyprinid fish populations, integrating with purely scholastic contents.

Motivation led to paper publication lays foundations on how scientific disciplines teaching/learning, especially biology, are based on information and contents learning not associated with practical experiential activities. In addition to scientific method competences, cognitive procedures of biological disciplines are entirely connected, particularly in zoology's case, whose judgment and interpretation's categories don't derive from common sense or spontaneous knowledge. This is particularly relevant for ichthyology in the light of general minimum possibilities or likelihood of freshwater fish observing and therefore of generating pre-existing knowledge experiences.

Objective of this research was to provide some possible ideas for repercussions reflection on learning paths of possible settings organized by school for scientific skills development in biology at the first cycle of students education end. With this assumption, methodological aspects' complexity, related to possible approaches by critical and experimental point of view to quantitative sampling specific problems of fish populations in lotic environments, was managed.

MATERIAL AND METHODS

Project involved two main phases. A first phase with frontal theoretical lectures and class exercises, concerning mathematical, biological and ecological aspects (hereafter reported), of studied stream fish species. Second experimental phase was developed in field, by means of quantitative fish sampling. Students, with their teachers, reached field work areas, attended all fish sampling phases performed by appropriately trained Asti Province's agents, and then worked independently through identification and counting of the caught. In the following days the class, in groups of two in the school premises, carried out statistical processing of obtained nature data. Project involved two training tests proposed to students respectively relating to theoretical and conceptual contents (Tab. I) and concerning experimental and specialized ones (Tab. II) of respective 50 and 100 minutes' time.

For research purposes, both correct answers and incorrect ones will be examined, as correct ones are an knowledge and skills's index, incorrect ones could hide possible misconceptions. In experience - unit of learning setting up, this general outline was followed in contents' proposal: prerequisites - objectives - materials and methods - verification. For prerequisite analysis, we used annual mathematics and science checks, considered representative of achieved learning levels, with reference to first two-year period of secondary school curriculum.

Operational definition of disciplinary objectives, referenced to Bloom's taxonomy, limiting attention to first levels' skills: knowledge, understanding, application. Simplified bibliographic sources concerning population ecology, qualitative and quantitative analytical

methods in ichthyology, information on investigation areas' characteristics and environmental status were proposed in elementary form.

Watercourses were identified by looking for less disturbed situations by environmental impact point of view. It was decided to identify such areas in Triversa Torrent basin according to this following different factors:

- Triversa drainage area includes most intact or with a reduced environmental impact river ecosystems compared to surrounding areas and falls almost entirely in Asti's province.
- Triversa drainage basin was the subject of investigation by the Province of Asti for over ten years, so a rich collection of data on ecological and mesological characters is available (Cortese, 1997, 2000, 2002)
- Triversa drainage basin is very close to the school and to pupil families' residential areas involved in project.

As methodological premise, didactic research's experience was placed in classical scientific method's phases, using brain storming technique and asking students to decline each phase's possible actions among the following:

- Observation
- Hypothesis
- Experiment
- Conclusion / Law

In particular, to articulate canonical method phases, excluding experiment (observation, hypothesis, conclusions), students were induced on field and subsequently to school reasoning.

Sampling areas were chosen by having the best fish populations' structuring, limited to investigation species, in order to optimize experience teaching value. They include a station on Traversola stream, just upstream from the confluence with Triversa stream in Scarassere locality of Villafranca d'Asti (Fig. 1) and a station located on Monale brook in Baldichieri d'Asti's village (Fig. 2). First station is characterized by a larger dimensions of width, flow rate, current speed, the second has lower values of morphometric and hydrological characters (Carta Ittica Regione Piemonte, 1992). Sampling areas are partly comparable to contribution of numerous territorial surface water tables, but differ in water course size, so to distinguish different operating methods in application of ichthyological analysis protocols and obtaine different estimates. To carry out representative quantitative samples of entire population, electro-fishing method seemed the most suitable in relation to morphological characteristics and size watercourses. Ichthyological analysis was conducted at a quantitative level by carrying out actual population's estimates and different fish species density. Setting standard was to focus attention to one or two specific parameters (populations' number and density) in order to simplify students' approach to new knowledge and skills, while leaving no greater understandability's qualitative aspects.

Samplings, lasting one morning, were carried out in 2003/2004 school year, one in autumn and the other in spring, through electro-fishing, subject to authorization by the Province of Asti, with a shoulder generator's help, whose proper operation has been calibrated to areas and fish species covered by the present survey. Capture tool choice was motivated with its multiple advantages, first of all fishing effort standardization, in order to

adjust experimental research to work protocol, accepted and shared among researchers. There are many advantages in this option. Among them, remarkable practical use, elimination of dimensional selectivity linked to nets use or to fish species ethological characteristics, but above all, according to density estimates, possibility to operate in an easier way to obtain standardization sampling effort. Specifically about sampling methodology, a comparative analysis was carried out among different scientific literature's ones, synthetically differentiable according to marking use or not.

Fig. 1. Traversola stream just upstream of the confluence with Triversa stream in Scarassere locality of Villafranca d'Asti's municipality.

Various types of marking have been synthetically described to students: drilling of one or more fins, colored tattoos with elastomeric polymer dyes, brand insertion of various shapes and sizes in different parts of body, inoculation of micro-emitters or radioactive substances. More in detail, operational and mathematical elements were subsequently analyzed (Ricker, 1958, 1968, Philippart, 1975). The first contemplate a fish first time sample, its identification and release at the same capture site and subsequent recapture after a sufficiently long time to allow full recovery by induced stress operations and also to ensure marked specimens dispersion both in the environment and within the population. With regard to the latter, Petersen procedure was proposed (Daget, 1971) according to which estimate of N dimensions population is as follows:

$N = cm / r$

ove

m = number of marked fish
c = number of caught fish with the second sample
r = number of marked recaptured fish with the second sample

This algorithm's mathematical basis, deriving from following proportion, was explained to students:

$N: m = c: r$

Fig. 2. Monale brok along the provincial road for Monale village in Baldichieri d'Asti's municipality.

Subsequently, sampling method's drawbacks were studied. Among them some elements' influence may affect estimate reliability: natural mortality, recruitment, immigration and emigration from population, need to mark a large number of fish to obtain recapture's significant percentages for quantitative evaluation purposes, waste of time resulting for the whole operation success, especially of smaller specimens' one than decimeter. Finally, it was agreed that all phases' correct execution would not eliminate the risk of obtaining not enough results for work's aims. It was therefore agreed to use rapid

succession repeated catches' method or removal method, whose statistical details were studied through analysis of specific literature and subsequently reported.

Electrofishing effort has been kept constant thanks to experience and adequate operator preparation. Census' program was structured to obtain density's estimates according to algorithms proposed by Moran (1951), Zippin (1956, 1958) and De Lury (1947), in accordance with Marconato's considerations (1992). Operationally, fluvial stretches of at least ten times to wet stream's width were tested, according to Verneaux's protocol (1981), going to probe all microhabitats determined by substrate - current velocity binomial, in order to obtain sufficiently indicative samples for statistical analysis' correct progress.

Density was calculated by applying successive catches method, limited to two electro-fishing steps only, considering wet bed's average width to allow entire population's representative samples. In particular, for second station, according to water body's limited dimensions, a single passage could be considered sufficient, however the different composition of substrate and reduced average depth areas' presence, less favorable to capture instrument's better performance, induced to considere a second pass as appropriate. Studied fluvial rods were isolated with fine mesh (0.4 mm) barrier networks, placed upstream and downstream, in order to prevent escape's phenomena, drift or immigration of fish compared to adjacent sectors. Fish fauna, once captured, has been kept alive in large lobster traps outside the sampled area.

Specimens collected were identified at a specific level, counted, measured and retained in a lobster pot. Once enough time has elapsed to allow residual population to redistribute normally in the station (about 1 hour), a subsequent sampling was carried out, holding the fish material collected as described above. Following study's beginning some preliminary sampling tests, a third electro-fishing passage hypothesis was rejected, as station's morphology and modest wet section's width showed the proceeding's uselessness to this further withdrawal, in relation to extremely low and not significant capture percentages estimate.

Uniformity of fishing effort makes it possible to assume that at each step a population's percentage fraction is removed, ie that, for a certain capture effort, individuals caught number is proportional to individuals present number in entire population at sampling time. Indirect De Lury's rating method (cited above) is based on this principle, consisting in carrying out several successive captures. Designating with X1, X2,..... Xn the cumulative number of captured fish following respectively the first (Y1), second (Y2),.... (Yn) caught, and with N the number of whole population's individuals at sampling moment (initial effective), we get:

$$Y1 = q\ (N - 0)\ for\ X1 = 0$$
$$Y2 = q\ (N - X2)\ for\ X2 = Y1$$
$$Yn = q\ (N - Xn)\ for\ Xn = Yn\text{-}1$$

By reporting graph in ordinate catches (Y) and in abscissa cumulate catches (X), representative points of each peach are aligned on a slope q line that meets the x axis in an abscissa's N point. In reality, points identified on the graph are never strictly aligned, so it is essential to determine regression line equation.

Students were initially explained that:

If *C* is the number of individuals caught in each draw, then we get:

C = qN where:
q = taken population's fraction (constant fishing effort)
N = individuals' number in entire population at the sampling time

Then if we define K = Σ C (sum of catches per catch), we get:

N = N initial - C1

and replacing we will have that:

C2 = qN = q (initial N - C1) = initial *qN - qC1* which is a linear function between *C* (catches for sample) and *K* (sum of catches)

Methodological elements related to regression line concept were explained later to students, who first limited themselves to calculate N population's estimate as value of abscissa axis' intercept of the straight line equation for two successive peaches's points, straight line identified with algorithm proposed by used text:

(Y - Y1) / (Y2 - Y1) = (X - X1) / (X2-X1)

A similar approach based on a different mathematical approach (binomial statistics) was proposed by Moran (1951) and Zippin (1956, 1958). N population's size estimate is obtained from the following algorithm:

A)

$$N = C/(1-Z)^{n}$$

where the specimens captured sum in i passages is determined as follows:

$$C = \sum_{n} C\,i$$

Z expresses the probability of non-capture and is given by z = (1 - p), where p (capture coefficient) is determined as follows:

$$P = 1 - C_i/(C_i - 1)$$

Seber (1973) and Seber & Le Cren (1967) have shown that if small size of stations and ethological peculiarities of fish species allow to reduce successive catches' number to two, calculation procedure leads to:

$$B)$$

$$N = C_i^2 / (C_i - 1)$$

While capability coefficient becomes:

$$P = 1 - C_2 / C_1$$

Students were explained through numerical examples so:

if $p = C1 / N = C2 / (N - C1)$, then

$N = C1 + C2 / p$, replacing p value relative to only two steps' protocol, we demonstrate previous formula B) for N calculation, from which, by replacing, we get general A) formula, valid for obtained data with n steps:

$C1^2 / C1 - C2 = (C1 + C2)\ C1^2 / C1^2 - C2^2 = (C1 + C2) / (C1^2 - C2^2)$ x $1 / C1^2 = (C1 + C2) / 1 - z^2$,

by which we will obtain A) formula generally.

Both calculation procedures used were analyzed.

RESULTS

Students fully shared that sampling was framed in scientific method's experimental phase and defined other canonical phases in this way:

- Observation:

1. I observe that there may be dead freshwater fish or aquatic organisms on watercourse
2. I observe that there are materials used to caught freshwater fish species
3. I observe that waterfowls feed on fish
4. I observe that there is a sewage discharge

- Assumptions

1. I hypothesize the mortality incidence on fish community
2. I hypothesize which species are the object of fishing and to what extent
3. I hypothesize which fish species are bird's food.
4. I hypothesize discharges' impact on fish populations

- Experiment

Datas' sampling and statistical analysis are part of experimental phase, common to ecological research that tries to give an answer to previous observations and hypotheses.

- Law

It may be the result of numerous cycles of application of scientific method. At present it is only possible to make some preliminary observation and considerations.

Project envisaged two training tests proposed to students respectively after the first part related to theoretical and conceptual contents (Tab.I) and after the second part concerning experimental and specialized ones (Tab. II).

Checks' results are summarized in Table III for theoretical and conceptual contents and in Table IV for experimental and specialized ones.

Theoretical and conceptual elements

Correct answer's percentage was 100% in one case and did not fall below 67%, with an average calculated on student total number equal to 81.99%. Average percentage error was equal to 18.01%. Six eighteen tests were performed correctly by all students. Most incorrect tests were found at n. 9 and n. 18 with a percentage error of 73.3% and 53.3% respectively. Error frequency of the remaining tests was lower or equal to 33.3%.

Experimental and specialized elements

Highest percentage of correct answers was 75% in two cases and did not fall below 34%, with an average calculated on the total students equal to 58.8%. Average percentage error was equal to 41.20%. Three tests out of forty-five were carried out correctly by all the students. Most incorrect tests were found at n. 14, n. 8, n. 22, with an error rate of 93.3%, 86.6%, and 80% respectively. Error frequency of remaining tests was less than or equal to 73.3%.

DISCUSSION

Analysis aimed to give a reason to students' answers. In particular, attention was paid to most frequent error's tests.

Theoretical and conceptual elements (tab III).

For n. 9 test, discarded the a) hypothesis of rigorously deterministic matrix, all errors, also scholastically prepared students' ones, have fallen on b) letter, or rather on probabilistic hypothesis' affirmation linked to theoretical-mathematical knowledge detached from scientific practice, especially used one in ecology studies, therefore not adhering to current shared scientist's vision. For n°18 test, discarded a) hypothesis, not conforming to scientific truth idea as shared and tested knowledge, error was addressed only to c) hypothesis, meaningless since scientific knowledge's application can only follow concluding considerations led to its discovery. Furthermore, term "application" itself does not usually appear on study's texts in classical name of scientific method's phases, as opposed to "experiment" or "verification". The presence of "application" term in correct

answer may have generated language difficulties. Final phase indicating of scientific method as obtaining conclusive considerations highlights how the current scientific training privileges verbal approach with respect to analytical one. This also emerges from answers given to n. 12, n. 7 and n. 5 tests. For these last two ones, errors refer essentially to cognitive disciplinary gaps as it seems to appear also by on both two wrong item's distribution. Obviously this is assumed, beginning from a certainly questionable consideration, especially in statistical terms, that, by didactic point of view, high error frequency values on a single item compared to low values on two items, are significant.

Also in n. 11 test error was focused on a) answer, in consequence of a little or no awareness researchersand's modus operandi and of very often necessity to complex calculations' rely carried out only with calculator support. Finally, remaining tests' errors can be attributed to incorrect disciplinary knowledge.

Experimental and specialized elements (tab IV).

N. 14 test is the most incorrect in absolute, with five responses of b) type, seven of c) type, the one without indication and the other only considered correct, both indicating analytical experimental achieved skills' absence, moreover not included among school work's prerequisites. Error was distributed between b) and c) alternatives, almost equally, indicating not wrong cognitive but incomplete acquisitions. Only one student seems to have understood determined by operators' sensitivity and experience role or by a methodological subjective component such to condition, even significantly, analysis adeguacy.

N. 22 test was wrong by twelve out of total fifteen students, only one of which didn't give any indication while eleven ones expressed a) item. If on one hand this denotes objective's acquisition lack leding to choice of specific methodology (methodological, operational reasons linked to the costs of the research), on the other it highlights how students have understood importance to obtain statistical method's treated data and that statistical elaboration can be instrument also useful for organizing synthetic and descriptive purpose data. Furthermore, answers also appears conditioned by current language of very common use "statistic" term.

N. 6 test was wrong by eleven out of fifteen students, of which eight answered a) item, one the c) item, two did not provide any answer: this situation denotes acquisition lack of IT tool potentials awareness in processing data field.

Only for three cases chosen c) item to number 33 question the answer is related to curriculum program carried out during school year concerning proportions and equations topics. According to n. 42 test we can see how 1/3 students confuse population estimate with density one, while just over 1/3 attribute the causes of errors to water quality. Probably estimation concept is difficulty understood in mathematical factors.

Following numbers 2 - 11 – 12 are among by at least 2/3 students' wrong tests:

In n. 2 test case, 80% error fell on the c) answer in relation to item term "hypothesis" presence, knowed by students since middle school's first class, because it's related to scientific method's terminology. An adequate reflection absence on the statement meaning and on the role's unfounded idea of hypothesis in result's phase verification, is obvious. Similar difficulties in scientific method's acquisition are clearly evident by n° 3 and n° 7 tests.

With regard to n. 11 and n. 12 tests, excluding c) answers, both banally incorrect, over 70% error is on a) answer, revealing how fundamental concepts, such as ecological

complexity, can't be acquired if detached by the practical case. This consideration is also attributable to n°10 test.

Among wrong tests for at least 1/3 students, there are number 1-3-7-9-19-20-21-23 - 25-27-31-33-34-35-37-43–44 tests.

N. 1 test's analysis answers demonstrate class group's incomplete acquisition of difference between experimental sciences defined as "exact" and not, even before complexity awareness of life phenomena.

Errors of N. 20-21-23-25-27-31-33-34-35 tests are due to gaps in statistics knowledge and understanding as in function study applied to biological research methodology.

For N. 37 and N. 42 tests, errors are exclusively related to experience's lack of field work, while tests N. 43 and N. 44 ones concern statistical factors of density estimation in quantitative ichthyology method. Compared to previous tests, these tests show completely independent errors by teacher and learner's work and by scholastic path of the latter ones, objectively ascribed to spects's involved complexity.

CONCLUSIONS

First of all IBSE methodology's research experiences or similar, even if innovative, have not been cited as different assumptions and not objectively comparable results with present work's ones, contextualized in middle school annual disciplinary didactic planning relating to "Mathematical, Physical, Chemical and Natural Sciences" teaching, accounting this particular experience with respect to canonical learning paths, meaning to specific ichthyological analysis' knowledge and skills provided for methodology.

Bibliographic materials were exemplified with lectures, subjected to simple exercises and discussed openly with brainstorming methodology, in order to ensure a preliminary theoretical preparation on ichthyological analysis' contents and specific skills. Consequently, in the field, students found themselves not only experimenting with new knowledge and skills but also checking those already learned. For example, in some cases, they pointed out to fish operators, during removal method's operational application, the lack of a microhabitat census, and, as technically predictable error, this was a preliminary information subject.

Intuitive erroneous conceptions or misconceptions, sometimes such as to be in contrast with accredited knowledge and to be structured as probable obstacles to learning, may not have been reworked in scientific learning course by scientifically correct cognitive restructuring processes, going to persist and to be used in daily life.

Educational and pedagogical conclusions can be multiple. Among didactic ones, limiting themselves to cognitive elemnts, the need to widen statistics disciplinary knowledge (with references to regression analysis and its practical applications), through adaptation of lower secondary school programs and information technology enhancement, emerges. First of all, the lack of applied mathematics use to pupil's reality study during the three-year schooling compulsory period emerges. This is particularly accentuated in biological field, even if it 's necessary to recognize other scientific disciplines, including physics, a traditional closer relationship with mathematical disciplines or with theoretical formalization even in a didactic sense. In many cases impression is that knowledge remains at a exclusively informative or even verbal level, without being anchored to particular and experimental cases, with consequences on simplest and most basic disciplinary learning.

Tests answers on theoretical and conceptual elements also indicate the lack of a complete and plural knowledge of various mathematics factors at the end of education first cycle. In general, many students tend to see in mathematics or algebra all mathematics with respect to which they lack a global and overall vision. In fact, in some cases, even Geometry itself is not formally recognized as a mathematical discipline, as can be seen by compulsory schooling daily practice.

Answers to experimental and specialized element's tests confirm what was said before, in relation to multiple methodological and organizational scientific research ones. On the basis of the answers one can understand how, for almost student's half, mathematics can not escape by considerable complexity aspects such as to be difficult for them to understand.

Overall students seem learned scientific method basic school scheme, overcoming phases' classic sequence of "observation, hypothesis, experiments, conclusions/laws"methodological paradigm, through basic acquisition of quantitative ichthyological analysis's specific operational skills, which allowed to broaden theoretical knowledge to studied biological elements' complexity.

Ichthyological analysis' specifics operational skills constituted a preliminary vehicle for disciplinary knowledge and skills as to design and application aspects of work protocols.

Certainly previously submitted evaluations on all scientific method's application phases, especially on protocol and sampling methodology, have led students, with whom they were shared and analyzed on field, to develop or enhance critical sense, interpretative keys and tools for processing information by integrating them around conceptual nodes comparable to structuring concepts (AA.VV., 1992) as suggested by 2012 National Indications (AA.VV., 2012). Overall, participants appeared interested and effective, having applied mathematical knowledge throught directly experiences lived, expanding typically informative and fragmented traditional approach's limits, experiencing a simple but significant attempt to compress the excessive reductionism and the little adapted trivialization to scientific learning of ecological and biological themes. Survey's extension to a larger and more articulated sample will allow statistically significant indications to be drawn, overcoming simple observation's boundaries as contribution's nature.

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RIASSUNTO

A quantitive approach to the ecology study for scientific learning in the lower secondary school

L' autore riferisce i risultati di uno studio condotto su una classe terza media volto a valutare le ricadute sugli apprendimenti delle conoscenze matematiche e scientifiche di base di un'esperienza didattica basata sulla metodologia della ricerca di campagna. Gli alunni sono stati preparati e valutati sugli aspetti teorici e pratici dell'analisi ecologica quantitativa dell'ittiofauna di due corsi d'acqua del Monferrato Astigiano (Regione Piemonte). Tra le conclusioni di ordine didattico, la necessità di ampliare le conoscenze disciplinari della statistica nelle programmazioni della scuola media inferiore ed una caratterizzazione meno accentuata nell'azione didattica degli aspetti formali e tecnici delle esperienze abitualmente proposte.

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APPENDIX I

Experimental project's first part theoretical and conceptual elements' test, as provided to the students through the experiment. The available time was 50 minutes.

1) What is science?

a) A complex instrument for mankind's study
b) Ourselves's knowledge and the world around us
c) An ecological framework

2) What is technology?

a) A techniques's set based on scientific knowledge's application
b) A method to improve human life
c) A way to save energy

3) What is a phenomenon?

a) A bouncing ball when it falls
b) A penalty kick not awarded by a football referee
c) A win on the football bet

4) An event is a phenomenon in the following cases:

a) If it can be forecasted and reproduced
b) If it can only be forecasted
c) If it can only be reproduced

5) What is a hypothesis?

a) A statement explaining a data collection
b) A statement explaining an observable phenomenon
c) A resulting statement by an experiment

6) What is an experiment ?

a) A phenomenon's reproduction under controlled conditions
b) A formulation of a previously proposed hypothesis
c) A processing of experimental data to derive conclusive considerations

7) What is a theory ?

a) An explanation which has never been rechecked as an absolute and unquestionable truth
b) A laws's set on a certain subject demonstrated by scientific method
c) An attempt to explain events that cannot be reproduced and forecasted

8) What is scientific method?

a) An acting way that starting from phenomenon's observation, through hypothesis' formulation and confirmation by one or more experiments, leads to a theory's formulation
b) A method to observe a phenomenon solely subjectively through one's own senses
c) A method allowing everyone to describe ecological relationship between living beings and environment in the same way

9) Which of the following statements is valid in the application of the scientific method?

a) An initial conditions's certain set leading to only one final conclusion
b) An initial conditions's certain set leading to a final conclusions's number each with its own chance of being true
c) Each event is unique and its very occurrence distinguishes it by all others

10) Do scientist use math?

a) Yes, because the scientific method requires defined quantities' measurement
b) Yes, only to apply elementary mathematical knowledge
c) No, as it is pure theory

11) Which part of mathematics do scientists use most today?

a) Algebra as adaptable to various needs
b) Analytical geometry, for drawing graphs possibility of describing studied elements
c) Information technology, to perform complex calculations quickly

12) The measurements can be:

a) Qualitative if they are accurate
b) Quantities if they are exact
c) Quantities if they determine categories

13) What is statistics?

a) A quantitative data collection and processing methods's set
b) All collecting and processing qualitative data's methods
c) All collecting and processing human data's methods

14) What is an algorithm?

a) An arithmetic literal expression based on the four fundamental operations
b) A complex geometric calculation
c) A series of algebraic operations necessary for a numerical calculation

15) What is an experimental protocol?

a) The scientific method steps's set
b) All experiment's methods publicly recognised and shared by scientists
c) A science study's innovative methodology

16) What is an experimental sample?

a) Small part of a study's objects set representative of all
b) Most of a study's objects set representative of all
c) The whole study's objects set representative of all

17) How should be sample:

a) It shall be non-random and linked to the investigator's expectations.
b) It shall be random and carried out according to an experimental protocol
c) It shall be carried out according to a non-experimental protocol

18) The last stage of the scientific method consists:

a) Conclusive considerations after some experiments and verifications
b) An experimental law after numerous applications and continuous testing
c) Final considerations only after numerous applications

APPENDIX II

Learning test of the project's second part (experimental and specialized elements)

1) Scientific method's application in biology takes on the following aspects:
a) Conclusions only change according to studied living beings' organization
b) Final conclusions have a higher probability of error than chemistry or physics'ones
c) Final conclusions have a higher probability of being true than chemistry or physics' ones

2) Advantages of mathematical models' use in scientific disciplines are:
a) Transformation of logical and verbal considerations into qualitative and predictive ones
b) Transformation of logical and verbal theories into quantitative and predictive ones
c) Results' verifiability by appropriate assumptions'means

3) Other advantages of mathematical models' use in scientific disciplines are:
a) Verifiability of quantitative predictions by experiments' means
b) Compatibility between theory and result cannot be tested with statistical methods
c) Verifiability of observations by assumptions' means

4) Using mathematical models in scientific disciplines is possible:
a) Predict only if a phenomenon's trend is increasing or decreasing
b) Identify phenomenon's trend by means of a functions' study
c) Only identify phenomenon occurring's time interval

5) Conclusions' validity in scientific investigation depends on the following factors:
a) A single observation
b) Three observations
c) A cycle of observations

6) Using mathematical models studying a phenomenon's evolution scientists observed that:
a) Phenomenon's evolution can be studied only under experimental conditions. without making further deductions'possibility
b) Phenomenon's evolution can be studied beyond experimental conditions' limits
c) Phenomenon's evolution can't never studied

7) Using mathematical models in formulating hypotheses on a phenomenon it is observed that:
a) New theories explained natural phenomena can be formulated
b) New assumptions can't be made about natural phenomena's development
c)New assumptions can be made about natural phenomena's development

8) Today biological phenomena are studied in this following way:
a) Simplifying them for practical needs
b) In their complexity and singularity
c) They are not studied because they are too complex

9) Is there an error's probability in experimental protocols' application in ecology?
a) No
b) Yes but always less than 30%
c) Yes, variable depending on studied system, also greater than 100%

10) Most commonly used algorithms' type in applied ecology is based on calculations

a) Simple (based essentially on four basic operations)
b) Uniquely complex (higher algebraic functions)
c) Only represented by straight lines

11) Ecological phenomena's study is carried out:

a) By breaking down a complex phenomenon in various simpler components, the sum of which allows an exact description, useful for general trand'sunderstanding
b) By breaking acomplex phenomenon down into several simpler components, the sum of which enables an inaccurate description but useful for general trand'sunderstanding
c) Studying a phenomenon all together without breaking it down into simpler components in order to avoid complexity's add elements

12) How can ecology's studied aspects be simplified?

a) By introducing very few simplifications, knowing that whole characteristics are its simple partial characteristics's sum
b) Introducing many simplifications, knowing that the whole characteristics are not its simple partial characteristics's sum
e) By introducing any simplification to consider all complexity's aspects

13) How sample has to be in animal populations's ecological study?

a) A small sample
b) A numerically representative sample of entire population
c) A sample covering entire population

14) Experimental phase's effectiveness in natural animal populations's ecological studies depends by the following factors:

a) Concerned operators' sensitivity and experience
b) Used instruments's high performance
c) Concerned operators' scientific knowledge

15) Experimental phase effectiveness in medium-high conductivity freshwater fish natural populations's ecological studies depends on the following factors:

a) Adjusting backpack electrofisher to high voltage and low pulse frequency
b) Adjust e backpack lectrofisher to capture larger specimens
c) Adjust backpack electrofisher to low voltage and high pulse frequency

16) Stram's work areas were identified in the following ways

a) They are similar to studied river ones stretch in environmental and faunal characteristics
b) They are like to a low-pollution area's ones
c) They are like a stream section with a current velocity of 80 centimetres for second.

17) Experimental phase effectiveness in natural fish population's density studies, conducted with haggling and recapture operations, depends on the following factors:

a) High induced stress on captured subjects
b) Minimum induced stress on captured subjects
c) No induced stress on captured subjects

18) Experimental phase effectiveness in natural fish population density's studies conducted by successive catches' method depends on these following factors:

a) Quantitative sampling's operators shall be the same at each experimental test cycle
b) High number of work's operators
c) Quantitative sampling's operators shall change at each experimental test cycle

19) The sampling fishing effort has to be exercised as follows:

a) A completely random fraction's population stock at the sampling time is taken
b) A variable fraction's population stock at sampling time is taken
c) A constant fraction's population stock at sampling time is taken

20) Two samplings' number was considered reliable for population density's estimation according to these following observations:

a) All fish were completely caught in the two catches.
b) One population's third wasn't taken in two catches
c) Very few specimens weren't taken in two catches

21) Between one sampling and the next, following operations carried out were:

a) Population's fraction remaining in the stream was allowed to redistribute itself normally inside the station
b) Subsequent sampling was carried out immediately to ensure entire population's sampling
c) Only three points of the previously sampled river stretch were sampled

22) The adopted sampling methodology's choice (removal method) was taken according to these following considerations:

a) Removal method provides statistical methods processable data
b) Marking-recapture methodology involved an exaggerated operational effort compared to actual work's requirements
c) The removal method provides much less exact information than marking – recapture one

23) The studied river stretch was isolated with upstream and downstream nets for these following reasons:

a) To eliminate fishes' movement of to/from adjacent river stretches
b) To maintain a constant fishing effort
c) To prevent escape to adjacent stretches

24) Considered z as non-capture probability, the probability of capture was determined as follows

a) p = l - z
b) p= l +z
c) p = z

25) In removal method's applying, procedure for calculating population's N dimensions was reduced to

a) N=C1 x CI /CI -C2
b) N = C I + C2 + C3
c) N = Cl +Cl /C1 C2

Where

C1 = number of caught specimens in first passage
C2 = number of caught specimens in second passage
C3 - number of caught specimens in third passage

26) An estimate is bad when:

a) C l= C2 xC2
b) C 1>C2
c) C1< C2

27) Subsequent catch method's application is based on this following theoretical assumption:

a) During sampling the population is closed and there is no mortality, immigration recruitment and emigration

b) Capture's probability is different for all individuals and changes during sampling

c) The catchable population is not the whole population

28) Subsequent catch method's applicability is based on this following theoretical assumption:

a) During sampling the population is not closed and there is mortality, immigration recruitment and emigration

b) The catchable population is not the whole population

c) Captch's probability is the same for all individuals and does not change during sampling

29) Subsequent catches method's principle is based is as follows:

a) The catch effort is constant and caught individuals' number is directly proportional to entire population's one

b) The trapping effort is not constant and caught individuals' number is inversely proportional to entire population's one

c) The catch effort is not variable and caught individuals' number corresponds to entire population's one

30) Some fish species population's numbers weren't estimated because of

a) Specimens' extremely small number

b) Specimens' excessive number

c) Less than one hundred specimens' number

31) Mathematical function linking fish caught number for catch to individuals' number present at the sampling time is of

a) Parabolic type

b) Hyperbolic type

c) Linear type

32) Mathematical function binding caught fish number for unit effort to caught fishes' total one is of

a) Parabolic type

b) Linear type

c) Hyperbolic type

33) Which mathematical procedure is applied to draw representative function straight line linking caught fishes' number for each catch to total ones in different samples?

a) Rationalisation

b) Proportion

e) Interpolation

34) Population density is:

a) A parameter alone enough to define population's dynamics together with individuals' biomass, age and sex ratio

b) A useful parameter to define population's structure together with individuals' biomass, age and sex ratio

c) An required parameter to define population's mortality together with individuals' biomass, age and sex ratio

35) The unit population density is expressed as:

a) Ratio between population headcount's number and sampled area
b) Ratio between caught specimens' total number and sampled area
c) Population headcount's number

36) Which of following situations has the greatest influence on capture's probability ?

a) Less than 10 centimetres depth in many areas
b) Boulders' presence in the stream
c) A low species' number presence

37) Which of following situations has the greatest influence on capture's probability?

a) Water quality
b) Specimens' reduced size
c) Aquatic invertebrates' presence

38) Subsequent catches method:

a) Tends to underestimate the true population density with a 20%.average error
b) Tends to overestimate true population density with a 20% average error
e) Indicates population density's precise value

39) It's true that:

a) Catchability tends to increase in subsequent catches
b) Error is inversely proportional to subsequent catches sampled individuals' percentage
c) Error is directly proportional to subsequent catches sampled individuals' percentage

40) When you want to report obtained density data in the sampled areas to a watercourse's larger section error may depend on:

a) There are no errors in this case
b) Density varies according to sampled areas
c) Density is constant in sampled areas

41) Ratings are more exact when

a) Sampled areas are chosen on type background - current velocity environmental variables' basis
b) Sampled areas is random chosen
c) Sampled areas number is reduced

42) An error's lower cause reporting obtained density data in the sampled areas to a watercourse's larger section may depend on:

a) Sampled area's estimated density
b) Sampled area's estimated population headcount
c) Sampled area estimated water quality

43) Density estimation's variance with subsequent catch method:

a) Increases as species catches and catchability number decreases
b) Decreases as species catches and catchability number increases
c) Decreases as species catches and catchability number decreases

44) Density estimate's variance is:

a) Proportional to population (N) number or size
b) Not proportional to population (N) number or size
c) Equal to population (N) number or size

45) Why are population density studies used for application purposes?

a) To obtain experimental data in theoretical studies

b) To obtain experimental data useful for water resource fish fauna rational management

c) For teaching purposes in school and university