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The use of modern relational databases for identification of fish larvae

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Summary

Fish larvae are often hard to identify because body proportions and pigmentation may change considerably in the course of larval development. Modern relational databases provide features such as **choice fields** (only one choice from a list of predefined entries is allowed for a field), **query-by-forms** (a very user friendly way of searching), and **graphics.** About 80 descriptive, meristic and metric characters of postlarvae have been recognized as useful for identification. For 126 species of fish larvae from the Northeast Atlantic these characters have been identified with values from the literature. It is shown that (a) a microcomputer-based database can be used to build a very efficient identification system, and (b) that drawings and descriptions from the literature can be successfully employed to build identification keys.

Résumé

Emploi de bases de données relationnelles modernes pour l'identification de larves de poissons

Les larves de poissons sont souvent difficiles à identifier parce que les proportions du corps et la pigmentation peuvent se modifier considérablement au cours du développement larvaire. Les bases modernes de données relationnelles offrent des dispositifs comme coice-fields (l'inscription dans une zone est choisie d'une liste pré-définie d'inscriptions possibles), query-by-forms (une forme de recherche d'utilisation facile) et graphiques. Environ 80 caractéristiques importantes de description, de dénombrement et de mensuration ont été choisies pour l'identification de postlarves. Pour 126 espèces de larves de poissons de l'Atlantique du nord-est ces caractéristiques ont été déterminées avec des données prises dans la littérature. Il est montré que a) un système d'identification efficace peut etre établi avec une base de données assistée par micro-ordinateur et que b) les dessins et descriptions pris dans la littérature peuvent être employés avec succès pour établir des clés d'identification.

Zusammenfassung

Benutzung moderner relationaler Datenbanken zur Identifizierung von Fischlarven

Fischlarven sind oft schwierig zu bestimmen, weil sich sowohl die Körperproportionen als auch die Pigmentmuster im Laufe der Larvalentwicklung beträchtlich verändern können. Moderne relationale Datenbanken bieten Möglichkeiten wie **choice-fields** (der Eintrag in ein Feld wird aus einer vordefinierten Liste von möglichen Einträgen ausgewählt), **query-by-forms** (eine sehr benutzerfreundliche Art des Suchens), und **Graphiken.** Ungefähr 80 wichtige beschreibende, zählende und vermessende Merkmale wurden für die Bestimmung von Postlarven ausgewählt. Für 126 Arten von Fischlarven des Nordostatlantiks wurden diese Merkmale mit Werten aus der Literatur gefüllt. Es wird gezeigt, daß (a) mit einer mikrocomputergestützten Datenbank ein sehr wirkungsvolles Bestimmungssystem aufgebaut werden kann, und daß (b) Zeichnungen und Beschreibungen aus der Literatur erfolgreich zur Erstellung von Bestimmungsschlüsseln genutzt werden können.

Introduction

This paper is the third in a series dealing with modern methods for identification of fish larvae. The first method was described as an expert system (Froese and Schöfer 1987) which seemed not only to be user friendly but also easy to handle whenever updating was required. However, except for ease of use it had no real advantage over traditional printed

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keys. The user still had to answer a series of more- or- less complicated questions to utilize the system effectively. The second method (FROESE 1988) emerged from the earlier exercise and employed a number of morphometric characteristics in conjunction with a powerful statistical approach (a combination of cluster analysis and quadratic discriminant functions). Although this method still looks very promising, it needs at least 50 well preserved specimens of each species involved for building a reliable key for identification. Experience has shown that, even in the Northeast Atlantic, it is almost impossible to easily obtain such numbers of specimens for more than about 30 fish species.

In order to improve further the use of a microcomputer-assisted identification technique, the present study was conducted to test two independent hypotheses: (A:) Modern microcomputer-based databases can be used to build very efficient identification keys, and (B:) Drawings and descriptions from the literature can be used to extract measurements and characters as input for the development of effective identification keys.

Material and methods

The database used

The commercial software package **DataEase** 4.0 was used for building the database. This package is very user friendly (menu-driven) and has all the features of modern databases such as: form generator, entry validation, choice fields, default fields, calculated fields, lookup fields, up to 100 links per view, calling of other programs (e.g. for graphics), query-by-forms including the use of operators and equations, and a powerful programming language. Its main advantage is the easiness with which links can be handled.

Choice fields

"Choice fields" is a modern user friendly version of the traditional "text field + thesaurus" concept and a replacement for the coding of text information. They are easy to search and enter, occupy only one byte of storage space for up to 60 characters of information, and prevent typing mistakes.

"Choice fields" is used whenever text information can be structured. The user is offered a choice from a predefined list of entries for a field. The options in the "choice fields" have to be unique and clearly defined: only one entry can be true. If a choice list does not cover all possibilities, the last choice of entry is "other".

Text fields

In addition to the normal use of "text fields" for names, they are used to allow for detailed descriptions of facts that cannot be completely classified by choice fields.

Max, min, mod

For many morphological data, such as "number of vertebrae", "diameter of eye", "depth of body", and others, there exists a natural variability. In most cases a maximum (max) and a minimum (min) value can usually be obtained from the literature and the mean, modal, or typical (mod) value is estimated by the user.

Early and late

Because of the change of morphological and descriptive characters during the course of larval development, several fields are in duplicate to allow entries for early and late post-larvae.

Table 1. **Test of the database identification system with 20 species of fish larvae.** Every species was identified twice: First, all seven morphometric measurements plus additional characters were used for identification. Second (below the dotted lines), those morphometric measurements that were not necessary for the identification were deleted. The last column shows the number of species which possess the described characters

Species	Characters used	Possible species
Clupea harengus	All measurements	* 2
Clupeidae	Ventral row of melanophores	1
	Depth above pectorals < 6.7%	* 6
	Ventral row of melanophores	1
Sprattus sprattus	All measurements	2
Clupeidae	Ventral row of melanophores	1
	Prenanal length > 65 and < 97%	14
	Depth above eye > 4 and < 7.4%	3
	Ventral row of melanophores	1
Argentina sphyrena	All measurements	1
Argentinidae		
	Preorbital length > 2.6 and < 4.9%	23
	Depth above eye > 8 and < 14.9%	13
	Depth above anus > 2.7 and < 5.1%	1
Maurolicus muelleri	All measurements	3
Gonostomatidae	Melanophores on head (early)	1
	Melanophores on head (early)	1
Stomias boa ferox	All measurements	* 1
Stomiatidae		
	Preorbital length > 3 and < 5.6%	37
	Depth above anus < 3.7%	* 1
Benthosema glaciale	All measurements	* 15
Myctophidae	No row of melanophores	1
	Preanal length > 40 and < 60%	90
	Preorbital length > 3.7 and < 6.9%	* 38
	Depth above pectorals > 11 and < 22.7%	* 25
	No rows of melanophores	1
Merlangius merlangus	All measurements	18
Gadidae	Dorsal and ventral row of melanophores	9
	Urostyle region pigmented	3
	Tail partly covered with melanophores	1
	Preorbital length > 5.2 and < 9.8%	78
	Dorsal and ventral row of melanophores	26
	Urostyle region pigmented	16
	Tail partly covered with melanophores	1
Micromesistius poutassou	All measurements	27
Gadidae	Dorsal and ventral row of melanophores	9
	Urostyle region unpigmented	5
	Tail with single melanophores	1
	Depth above pectorals > 15.7 and < 29.1%	60
	Dorsal and ventral row of melanophores	26
	Urostyle region unpigmented	9
	Tail with single melanophores	1

Species	Characters used	Possible species
Pollachius pollachius	All measurements	17
Gadidae	Dorsal, ventral, and lateral row of mel.	5
	Urostyle region unpigmented	3
	Tail with single melanophores	1
	Dorsal, ventral, and lateral row of mel.	17
	Urostyle region unpigmented	6
	Tail with single melanophores	1
Pollachius virens	All measurements	24
Gadidae	Dorsal, ventral, and lateral row of mel.	6
	Two dorso-ventral clusters	1
	Dorsal, ventral, and lateral row of mel.	17
	Two dorso-ventral clusters of mel.	1
Gadiculus argenteus thori	All measurements	15
Gadidae	No rows of melanophores	6
	Urostyle region unpigmented	3
	One dorso-ventral cluster of mel.	1
	No rows of melanophores	42
	Urostyle region unpigmented	18
	One dorso-ventral cluster of mel.	1
Scomber scombrus	All measurements	* 9
Scombridae	Dorsal and ventral row of melanophores	2
	Urostyle region pigmented	1
	Preanal length > 33.2 and < 49.8 %	46
	Prepectoral length > 15 and < 27.9 %	* 32
	Depth above pectorals > 13.7 and < 25.5 %	19
	Depth of tail behind anus > 7.7 and < 14.4 %	13
	Dorsal and ventral row of melanophores	2
	Urostyle region pigmented	1
Lebetus scorpioides	All measurements	7
Gobiidae	Dorsal, ventral, and lateral row of mel.	1
	Prepectoral length > 16.3 and < 30.3 %	82
	Dorsal, ventral, and lateral row of mel.	1
Cristallogobius linearis	All measurements	* 18
Gobiidae	Ventral row of melanophores	4
	Gas bladder pigmented	3
	Tail with single melanophores	1
	Depth above eye > 12.5 and < 23.2 %	59
	Ventral row of melanophores	12
	Gas bladder pigmented	3
	Tail with single melanophores	1
Helicolenus dactylopterus	All measurements	2
Scorpaenidae	Ventral row of melanophores	1
	Preorbital length > 7.3 and < 13.6 %	44
	Depth of tail behind anus > 7.8 and < 14.4 %	17
	Ventral row of melanophores	1
Glyptocephalus cynoglossus	All measurements	1
Pleuronectidae	Preanal length > 24.8 and < 37.1 %	5
	Depth above pectorals > 6.6 and < 12.2 %	3
	Depth of tail behind anus > 3.8 and < 7 %	1

Species	Characters used	Possible species
Lepidorhombus boscii	All measurements	* 4
Bothidae	Gas bladder pigmented	2
	More than 2 dorso-ventral clusters of mel.	1
	Depth behind anus > 12.3 and < 23.9 %	50
	Gas bladder pigmented	7
	More than 2 dorso-ventral clusters of mel.	1
Microchirus variegatus	All measurements	4
Soleidae	Dorsal and ventral row of melanophores	3
	Tail completely covered with mel.	2
	Pectorals with marginal mel.	1
	Dorsal and ventral row of melanophores	26
	Tail completely covered with mel.	5
	Pectorals with marginal mel.	1
Solea solea	All measurements	* 4
Soleidae	Dorsal and ventral row of melanophores	3
	Tail partly covered with melanophores	1
	Depth above eye > 27 and < 50.7 %	* 14
	Dorsal and ventral row of melanophores	4
	Tail partly covered with melanophores	1
Lophius piscatorius	All measurements	1
Lophiidae	Preanal length > 26.9 and < 40.4 %	10
	Preorbital length > 4.4 and < 8.2 %	5
	Depth of tail behind anus > 5.6 and < 10.4 %	1

* The asterisk indicates that the applied range of +/– 20 or 30 % was not enough to find the correct species, i. e. the respective value contained in the database was larger or smaller. The adjusted range is given in the list.

The LARVAE table has a "Main Ref" field which contains the number of the reference (in another table) from which data originate. In addition, every important entry has its own reference field. If the source of such a referenced entry is the same as the main reference, then the "Ref" field may be left blank.

The structure of the larvae table

The larvae table is part of a large database about fish. It is not only meant for identification but also for all kinds of comparative studies.

Environmental parameters

The following parameters related to time and environment are provided:

Months of presence of larvae, Reference
Depth of capture (max, min, mod), Reference
Temperature (max, min, mod), Reference
Salinity (max, min, mod), Reference
pH (max, min, mod), Reference
Oxygen (max, min, mod), Reference

Descriptive characters

The following descriptive characters are provided:

Drawings of several developmental stages of the larva
Striking features
Striking shape, lateral and dorsal
Shape of gut
Visibility and pigmentation of gas bladder, early and late
Spinal armature, early and late
Pigmentation of tail, early and late
Pigmentation of head and trunk, early and late
Pigmentation of urostyle region, early and late
Pigmentation of peritoneum
Appearance and pigmentation of pectoral fins
Appearance and pigmentation of pelvic fins
Additional descriptive characters (Text)

Meristic characters

The following meristic characters are provided:

Total number of myomeres/vertebrae (max, min, mod), Reference
Preanal number of myomeres/vertebrae (max, min, mod), Reference

Morphometric characters

The following morphometric characters are provided:

Reference length (RL) (max, min, mod), Reference
Type of Reference length (SL, TL, other)
Preanal length (% RL) (max, min, mod)
Prepectoral length (% RL) (max, min, mod)
Preorbital length (% RL) (max, min, mod)
Diameter of eye (% RL) (max, min, mod)
Depth above eye (% RL) (max, min, mod)
Depth above pectoral fins (% RL) (max, min, mod)
Depth of tail behind anus (% RL) (max, min, mod)

Source of information

The database now contains all larvae (126 species) that are reported to occur in the North Sea. All measurements and characters used in the database were extracted from drawings and descriptions provided by the following authors: ABOUSSOUAN 1964, AHLSTROM 1984, ARBAULT and BOUTIN 1968, BERTOLINI et al. 1931, DAHL et al. 1984, DEMIR and DEMIR 1961, DEMIR 1986, EGE 1930, EHRENBAUM 1904, 1905, 1936, FAGE 1908, FAHAY 1983, FIVES 1986, FRASER and MUUS 1965, HALBEISEN 1988, MARINARO 1971, NICHOLS 1971, PETERSEN 1906, RE' 1977, RUSSELL 1976, SCHMIDT 1905, THOMOPOULOS 1954, 1956.

Material

The test of the database identification system was conducted with larvae sampled in the Celtic Sea in April 1986. The larvae were pre-identified independently by A. RÖPKE, University of Hamburg. From these samples we selected, by naked eye, larvae that appeared complete and well preserved. Once a larva was selected, it was used for the test regardless of whatever problems arose. A total of 20 species from 13 families were selected to perform the test.

Method of testing

First, all seven morphometric measurements (see above) were conducted on each larva using an image analysis system. (A video camera with macro optics captures an image of a larva and displays it on a video monitor where it can be measured very accurately with a mouse-driven cursor.) The measurements were transformed in % standard length and entered in the search form of the database with a range of +/− 20 % for preanal length and +/− 30 % for the other measurements (e. g. for a preanal length of 50 % standard length, the entry in the database was: > 40 % and < 60 %). A first search was conducted to see how many species resemble the proportions of the unknown larva. If more than one species appeared in the resulting list, one additional descriptive character was entered and the search was repeated. This procedure was continued until only one species was left on the list.

Second, one morphometric measurement after the other was deleted to see which measurements from the list of 7 were really needed for the final identification.

Results

The results of the test are listed in table 1. They can be summarized as follows:

- All larvae could be identified.
- Half of the larvae could be identified using only 3 characters (minimum 1 character, maximum 6 characters).
- Four identifications were performed with morphometrics only, five with descriptive characters only, and eleven with morphometric and descriptive characters.
- Overall, 29 morphometric and 32 descriptive characters were used for identification.
- From 140 measurements that were made on the real larva, in 8 cases the range applied to the measurements (i. e. +/− 20 or 30 %) was too narrow to include the value from the literature contained in the database. The range was then enlarged to find the correct species. These cases are marked with an asterisk * in the listing.

Discussion

Hypothesis A

In the light of these results, modern databases seem to be appropriate tools for building identification systems. The average of three easily obtained characters for an identification is a distinct advantage over the traditional identification keys.

Morphometrics and descriptive characters seem to be of comparable use for identification. However, inexperienced users often prefer to take measurements instead of searching for uncertain characters.

Hypothesis B

The results demonstrate that measurements and characters extracted from the literature can be successfully used to build identification keys. Because there is a rich (but scattered) literature with drawings and descriptions of fish larvae from all over the world, this offers possibilities for areas where no keys are available and pre-identified real larvae normally cannot be obtained.

However, we feel that whenever a reasonable number of real larvae is available, they should be used to check and improve the measurements and characters obtained from the literature.

A proposed strategy for searching

From our preliminary experience, especially the problem of the range to apply to the measurements, the following strategy of searching seems to be appropriate to identify an unknown larva:

Measure larva

From the seven presented measurements, perform as many as can be obtained easily and accurately. Enter them with a range of +/− 25 % for preanal length and +/− 33.3 % for all others. Begin the search. If there are more than five species on the resulting list, proceed with *Additional Characters*. If there are 1 to 5 species on the list, proceed with *Check Pictures*. If there is no listing, check the entries and the measurements for possible errors. If no error can be found, delete those measurements which are most uncertain and repeat the search. If there is still no listing, the larva does not match any entry for the species in the database.

Additional characters

Examine the larva for a striking, distinct character, enter it in the search form and run a search. If there is no striking character, start with pigmentation of the tail or urostyle region. If there are more than five species on the resulting list, proceed with the next definite character. If there are 1 to 5 species on the list, proceed with *Check Pictures*. If there is no listing, delete the last entered character and try a different one. If this does not help, check the measurements.

Check pictures

Compare the pictures of all species on the list with your larva. Proceed with *Check all characters* for the species that resembles your larva most closely. If your larva resembles none of the species on the list, use the check options described in *Additional characters* and measure larva.

Check all characters

When you are quite certain of the identity of your larva, the complete information about the species should be displayed on the screen. Carefully check all the provided characters to ensure your identification.

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