A Computerized "Expert System" to Aid in the Identification of Juvenile Rockfish (Genus Sebastes)

By

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ABSTRACT

Identification of pelagic juvenile rockfish (genus Sebastes) is difficult because of the large number of species in the genus and their differences from adults. Identification of juveniles from stomach contents is even more difficult because digestion often eliminates key characters. Under these conditions, we need an identification tool that is completely flexible, that would allow us to use whatever identification characteristics are available, and that would return a list of the possible species. The result of our efforts is the "expert system" JUVROCK which is based on meristics (gill raker counts, dorsal, pectoral, and anal fin ray counts) and the presence or absence of the supraocular spine. The system is described in detail, along with several examples of its use.

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INTRODUCTION

The identification of juvenile rockfish (genus Sebastes) is extremely difficult because of the large number of species in the genus. Rockfishes number at least 62 species in northeastern Pacific waters and over 100 species worldwide (Eschmeyer et al. 1983). To further complicate identification of specimens, the major taxonomic works (Phillips 1957, Miller and Lea 1972, Hart 1973, Eschmeyer et al. 1983, and Chen 1986) all deal with adult fishes and are not appropriate for pelagic juveniles which have dramatically different color patterns (Anderson 1983). It was only recently that Richardson and Laroche (1979), Laroche and Richardson (1980, 1981), Anderson (1983), and Matarese et al. (1989) published information for pelagic juvenile rockfishes.

When working with specimens from stomach contents, the problems of identifying juvenile rockfish are compounded by digestion. Color pattern, often the key identification factor (Anderson 1983), is almost always missing. Frequently meristics - dorsal, pectoral, or anal fin rays or head spines - are also missing. Fortunately, gill rakers are the most descriptive meristic, and the last to be lost to digestion. Identification techniques used under these conditions must be as flexible as possible, since the combination of meristic data available changes with each specimen. For this reason, dichotomous keys are too restrictive.

What is needed is a flexible tool that allows the identification of juvenile rockfish based on meristics. Computer programs of this type are called "expert systems" (Townsend 1986). It would have to be able to accept whatever combination of meristics that is available and return a list of possible species, ideally with some measure of probability as to which is the most likely. Another desired aspect of an identification tool would be that, once the identification is narrowed down to a group of two or more species, the system could be queried as to the best meristic that would further identify the specimen. One characteristic of computerized keys is that they are much easier to update as new information becomes available. The result of efforts to develop such an identification tool is the "expert system" that we use at the Tiburon Laboratory to identify juvenile rockfish from predator stomach contents.

SOURCES OF DATA

The "expert system" described here is a way of combining and displaying meristic data. The meristics used here are gill raker counts, dorsal, pectoral, and anal fin ray counts, and presence or absence of a supraocular spine. The 45 rockfish species for which we were able to obtain this meristic data and which are included in the key are listed in Appendix I.

Gill raker counts are the meristic which has the greatest ability to discriminate between species or groups of species. Gill raker counts were taken primarily from the same data used by

Moreland and Reilly (1991), but were augmented by data from counts on trawl-caught juveniles and from Chen (1986). Dorsal, pectoral, and anal fin ray counts, and presence or absence of a supraocular spine were taken either from the same data used by Moreland and Reilly (1991) or Chen (1986).

PROGRAM DESCRIPTION AND EXAMPLES

The "expert system" JUVROCK is written in the computer language PROLOG. PROLOG is a highly flexible language that allows the user to query the basic data in many different ways. The program is made up of a number of statements called predicates, one for each meristic type. We will deal with the statement for gill rakers as an example, which has the form

gillraker(count,species,probability),

where count = the number of gill rakers, species = the rockfish species associated with that count, and probability = the probability that an individual with that gill raker count is this particular species. For example, the first gill raker statement is

gillraker(34,alutus,0.60),

which means that for gill raker count of 34, there is 0.60 percent probability that the species is S. alutus. For a rockfish with 34 gill rakers, there are a total of 20 possible solutions (species); the most likely is S. diploproa with a probability of 16.36 percent, closely followed by S. brevispinis

with a probability of 15.46 percent. The meristic data for dorsal, pectoral and anal fin rays have similar statements:

dorsal(count,species,probability),

pectoral(count,species,probability),

anal(count,species,probability),

where the variables have the same meaning as above. The statement for presence and absence of the supraocular spine is

supraoc(occur,species),

where occur = either present or absent, and species = species associated with the presence or absence of the supraocular spine.

The program is queried by entering one or a combination of these statements within the Dialog window. The statements are typed at the prompt Goal: with numbers (meristics) or lowercase words (species) in place of variables that are known and uppercase words in place of variables that are unknown. After the "Enter" key is pressed, the program returns a list of possible species along with probabilities of how commonly that species has this meristic. The system can then be queried further in this way by adding more meristic categories or by inquiring about differences that would separate the most likely species.

The easiest way to understand the use of the program is through example. If a specimen has a gill raker

Dialog

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Goal:
gillraker(47,Species,Prob)
Species=jordani, Prob=100
1 Solution
Goal:
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Figure 1. First example.

count of 47 (Fig. 1), at the prompt Goal:, type in the gillraker query with a count of 47, an uppercase variable name for the species (Species) and an upper case variable name for the probability (Prob). The program will match the input data and return all possible solutions. In this case, there is only one possible solution, S. jordani, and the probability is 100 percent. A more complicated example (Fig. 2) starts with a query for a gill raker count of 35. This returns 16 possible solutions, of which S. rufus, S. zacentrus, S. mystinus, S. brevispinis, S. serranoides, and S. diploproa are the most likely. A count of 10 anal fin rays in addition to the gill raker count returns only 2 solutions, S. mystinus and S.

Dialog

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Goal: gillraker(35,Species,Prob)
Species=alutus, Prob=8.02
Species=atrovirens, Prob=0.99
Species=brevispinis, Prob=9.66
Species=chlorostictus, Prob=1.78
Species=crameri, Prob=0.24
Species=diploproa, Prob=8.88
Species=entomelas, Prob=7.09
Species=flavidus, Prob=3.72
Species=goodei, Prob=4.19
Species=macdonaldi, Prob=0.40
Species=melanops, Prob=2.58
Species=mystinus, Prob=10.87
Species=rufus, Prob=15.04
Species=saxicola, Prob=2.65
Species=serranoides, Prob=9.65
Species=zacentrus, Prob=14.26
16 Solutions
Goal: gillraker(35,Species,Prob)
and anal(10,Species,Prob2)
Species=mystinus, Prob=10.87,
Prob2=16.67
Species=serranoides, Prob=9.65,
Prob2=5.56
2 Solutions
Goal: supraoc(Occur,mystinus)
Occur=present
1 Solution
Goal: supraoc(Occur,serranoides)
Occur=absent
1 Solution
Goal: gillraker(35,Species,Prob)
and anal(10,Species,Prob2) and
supraoc(present,Species)
Species=mystinus Prob=10.87,
Prob2=16.67
1 Solution
Goal:
```

Figure 2. Second example.

serranoides. Then, how useful the presence or absence of the supraocular spine would be in distinguishing between these species can be investigated by typing in the supraoc query with the two species names, and, in fact, the presence or absence would distinguish between the two species. Finally, a combination query of gill raker count, anal fin ray count, and presence of the supraocular spine returns only one solution, *S. mystinus*. Often it will not be possible to identify the specimen to a single species, but even narrowing down the possibility to several species may allow identification when other information such as geographical or depth range, reproductive seasonality, and identification of other specimens within the same collection are used.

We have improved the identification of juvenile rockfish from 63% to over 95%, and the use of this "expert system" has been a major reason. Even the specimens not identified to species are identified to a limited group of species. Documentation and a copy of the program are available from the senior author.

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Appendix I. A list of the species of juvenile rockfish (genus *Sebastes*) included in the computerized "expert system" JUVROCK.

Sebastes alutus
S. atrovirens
S. auriculatus
S. aurora
S. babcocki
S. brevispinis
S. carnatus
S. caurinus
S. chlorostictus
S. chrysomelas
S. constellatus
S. crameri
S. diploproa
S. elongatus
S. entomelas
S. flavidus
S. goodei
S. helvomaculatus
S. hopkinsi
S. jordani
S. levis
S. macdonaldi
S. maliger
S. melanops
S. melanostomus
S. miniatus
S. mystinus
S. nebulosus
S. nigrocinctus
S. ovalis
S. paucispinis
S. pinniger
S. proriger
S. rastrelliger
S. rosaceus
S. rosenblatti
S. ruberrimus
S. rubrivinctus
S. rufus
S. saxicola
S. semicinctus
S. serranoides
S. serriceps
S. wilsoni
S. zacentrus

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METHODS USED TO IDENTIFY PELAGIC JUVENILE ROCKFISH (GENUS *SEBASTES*) OCCURRING ALONG THE COAST OF CENTRAL CALIFORNIA

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