FORTRAN Program for Calculating Brillouin's Species Diversity Index

Throughout the past 30 years, numerous measures of species diversity have been proposed (Wihlm 1967; Dickman 1968; Cairns et al. 1968; McErlean and Mihursky 1968). Recently, Kaesler et al. (1978), based on the work of Pielou (1975; 1977, 291-311), discussed the choice of a diversity index, and concluded that for most cases, Brillouin's index is the preferred index for most problems in applied aquatic ecology. Kaesler et al. (1978) further stated that Brillouin's index is "not a statistical estimate but an actual measurement of the diversity of the working ecologist's basic unit—the sample."

The formula for Brillouin's index is

$$H = \frac{1}{N} \ln \frac{N!}{N_1!\, N_2! \ldots N_s!}$$

where H is equal to diversity; N the total number of individuals in the sample; N_1, N_2, . . ., the number of individuals in species 1, 2, . . .; and s the total number of species in the collection (Pielou 1977). As noted by Kaesler et al. (1978), use of this index has not been popular due to the difficulty in calculating large factorials. As a result, an approximate index has been used which replaces N (1n N −1) for 1n N!. Kaesler et al. (1978) compared the values of the two preceding formulas for various N's and concluded that for small N's an unacceptable error is introduced into the calculation of H. This phenomenon becomes critical since it is those samples which have small numbers of individuals that are usually of greatest importance in assessing stressed ecosystems. The purpose of this paper is to present a computer program for the calculation of Brillouin's di-

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      REAL ITS,IBS,NSUM,IAM,IOT
      INTEGER DUM,STNUM
      DIMENSION ISP(900),NSP(900),IAM(900),
     1   SYM(80)
      READ(5, 5) SYM
    5 FORMAT (80A1)
      JII=0
   10 READ(5,SYM) ITTS,ITTD,ITNUM
      ISUM=0
      IRD=0
      NMU=0
      NUM=0
      MA=0
      JM=0
      NM=0
      JUM=0
      NEMP=0
      MEMP=0
      IOT=0
      KOUNT=0
      NSUM=0
      IBS=0
      ITS=0
      H=0
      NE=0
      JII=JII+1
      IF(JII .NE. 1) GO TO 15
      STNUM=ITTS
      ISP(JII)=ITTD
      NSP(JII)=ITNUM
      GO TO 10
   15 IF(STNUM .NE. ITTS) GO TO 20
      ISP(JII)=ITTD
      NSP(JII)=ITNUM
      GO TO 10
   20 IRD=JII-1
      IF(IRD .EQ. 1) GO TO 135
      DO 25 I=1,IRD
      NE=I
   25 IF(ISP(I) .EQ. 0) GO TO 30
      GO TO 35
   30 NE=I-1
   35 NMU=NE-1
      DO  50 I=1,NMU
      NUM=NE-1
      MA=I+1
      DO  45 M=1,NUM
      IF(ISP(I) .NE. ISP(MA)) GO TO 40
      ISP(MA)=0
      NSP(I)=NSP(I)+NSP(MA)
      NSP(MA)=0
   40 MA=MA+1
   45 CONTINUE
   50 CONTINUE
      NM=NE-1
      DO  60 I=1,NM
      JM=NE-1
      DO  55 K=1,JM
      IF(NSP(K) .LE. NSP(K+1)) GO TO 55
      NEMP=ISP(K)
      MEMP=NSP(K)
      NSP(K)=NSP(K+1)
      ISP(K)=ISP(K+1)
      NSP(K+1)=MEMP
      ISP(K+1)=NEMP
   55 CONTINUE
   60 CONTINUE
      WRITE(6, 65) STNUM
   65 FORMAT('1','THE STATION NUMBER
     1   IS',1X,I3)
      WRITE(6, 70)
   70 FORMAT('0','SPECIES',3X,'NO. OF ORG.')
      DO  80 I=1,NE
      WRITE (6, 75) ISP(I),NSP(I)
   75 FORMAT(' ',T4,10X,I4)
   80 CONTINUE
      DO 110 I=1,NE
      NSUM=NSUM+NSP(I)
      IF(ISP(I) .EQ. 0) GO TO 110
      KOUNT=KOUNT+1
      IF(KOUNT .NE. 1) GO TO 90
      IOT=NSP(I)
      DUM=NSP(I)
      DO  85 M=1,DUM
      IAM(1)=IAM(1)+ALOG(IOT)
   85 IOT=IOT-1
      GO TO 105
   90 IF(NSP(I) .NE. NSP(I-1)) GO TO 95
      IAM(KOUNT)=IAM(KOUNT-1)
      GO TO 105
   95 DUM=NSP(I)
      IOT=NSP(I)
      JUM=NSP(I-1)+1
      DO 100 M=JUM,DUM
      IAM(KOUNT)=IAM(KOUNT)+ALOG(IOT)
  100 IOT=IOT-1
      IAM(KOUNT)=IAM(KOUNT)+IAM(KOUNT-1)
  105 KAP=NSP(I)+1
  110 CONTINUE
      IOT=NSUM
      ISUM=NSUM
      DO 115 JAP=KAP,ISUM
      ITS=ITS+ALOG(IOT)
  115 IOT=IOT-1
      ITS=IAM(KOUNT)+ITS
      DO 120 I=1,KOUNT
  120 IBS=IBS+IAM(I)
      H=(ITS-IBS)/NSUM
      WRITE (6,130) H
  130 FORMAT('0',6X,'BRILLOUIN S SPECIES
     1   DIVERSITY INDEX =',F10.4)
      GO TO 145
  135 WRITE(6,140) STNUM
  140 FORMAT('1','THERE IS ONLY ONE
     1   SPECIES PRESSENT AT STATION',1X,I3)
  145 IF(ITTS .EQ. 0) GO TO 999
      DO 150 I=1,900
      ISP(I)=0
      IAM(I)=0
  150 NSP(I)=0
      JII=1
      ISP(JII)=ITTD
      STNUM=ITTS
      NSP(JII)=ITNUM
      GO TO 10
  999 STOP
      END
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Fig. 1. Listing of the FORTRAN program which calculates Brillouin's species diversity index. See text for documentation.

versity index which does not use an approximation of N! (Fig. 1).

The basic features of the program follow:

- Each sample is sorted in an ascending order by the number of individuals in each species.
- Natural logarithms are used to calculate N! for that species represented by the smallest number of individuals.
- This information is stored and subsequently used to calculate N! for the next species. The process continues until N! is calculated for the total sample.

Because space limitations prohibit the use of comment cards throughout the program, the essential features are discussed. The main data set must be preceded by a parameter card, of the form (I2, 1x, I2, 1x, I3), which describes the format of the data. Specifications on this card are variable and can take any form except that the station number (ITTS), species identification number (ITTD), and number of organisms (ITNUM) must appear on the data cards in sequential order. The program does not require that data be arranged by sequential station numbers, species identification numbers, or numbers of organisms; however, all of the observations from a particular station must be grouped together. The program will add the number of organisms for those cards which have identical species identification and station number designations. The data set must be followed by a blank card, which will terminate the program. The program outputs the species identification number along with the number of specimens for each species and the diversity index for each station. Additional documentation or examples of sample data sets are available at the Appalachian Environmental Laboratory.

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