

In this example we will learn how to use `fitPS` to fit a zeta distribution to some data from a survey where the number of groups of glass found is recorded. The data in this example comes from @roux2001 who surveyed the footwear of 776 individuals in south-eastern Australia, and is summarised in the table below.

$n$	$r_n$
0	754
1	9
2	8
3	4
4	1

This data set is built into the package and can be accessed from the `Psurveys` object. That is, we can type:

```
> data("Psurveys")
> roux = Psurveys$roux
```

The data is stored as an object of class `psData`. This probably will not be of importance to most users. If you are interested in the details, then these can be found in the **Value** section of the help page for `readData`. There is an S3 `print` method for objects of time, meaning that if we print the object—either by typing its name at the command prompt, or by explicitly calling `print`—then we will get formatted printing of the information contained within the object. Specifically:

- the values of  $n$  and  $r_n$  will be printed out in tabular format (where  $n$  is the number of groups or the size of the groups, and  $r_n$  is the number of times  $n$  has been observed in the survey),
- the type of survey will be printed—either "Number of Groups" or "Group Size",
- and if the object has a reference or notes attached to it, then these will be printed as well

For example

```
> roux

Number of Groups

  n    rn
--- ----
  0   754
  1     9
```

```

2      8
3      4
4      1
Roux C, Kirk R, Benson S, Van Haren T, Petterd C (2001).
"Glass particles in footwear of members of the public in
south-eastern Australia-a survey." _Forensic Science
International_, *116*(2), 149-156.
doi:10.1016/S0379-0738(00)00355-8
<https://doi.org/10.1016/S0379-0738%2800%2900355-8>.

```

It is very simple to fit a zeta distribution to this data set. We do this using the `fitDist` function.

```
> fit = fitDist(roux)
```

The function returns an object of class `psFit`, the details of which can be found in the help page for `fitDist`. There are both S3 `print` and S3 `plot` methods for objects of this class. The `print` method displays an estimate of the shape parameter  $s$ , an estimate of the standard deviation—the standard error—of the estimate of  $s$  ( $\widehat{sd}(\hat{s}) = se(\hat{s})$ ). **\*\*NOTE\*\***: it is important to understand that the value of the shape parameter that is displayed, and the value that is stored in the fitted object differ by 1. That is,  $s$  is shown,  $m$  and  $s' = s - 1$  is stored. This is done because the package which assists in the fitting, `VGAM`, is parameterised in terms of  $s'$ . This difference only has consequences if the fitted value is being used in conjunction with other `VGAM` functions. The `print` method also displays the first 10 fitted probabilities from the model by default.

```
> fit

The estimated shape parameter is 4.9544
The standard error of shape parameter is 0.2366
-----
NOTE: The shape parameter is reported so that it is consistent
with Coulson et al. However, the value returned is actually s'
= shape - 1 to be consistent with the VGAM parameterisation,
which is used for computation. This has flow on effects, for
example in confInt. This will be changed at some point.
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The first 10 fitted values are:
      P0      P1      P2      P3      P4
9.631547e-01 3.106447e-02 4.167082e-03 1.001917e-03 3.316637e-04
      P5      P6      P7      P8      P9
1.344002e-04 6.262053e-05 3.231467e-05 1.802885e-05 1.069709e-05

```

The package provides a `confint` method for the fitted value. The method returns both a Wald confidence interval and profile likelihood interval. The Wald

interval takes the usual the form where the lower and upper bound are given by  $\hat{s} \pm z^*(1 - \alpha/2) \times se(\hat{s})$ . The profile likelihood interval finds the end-points of the interval that satisfies

$$-2[\ell(\hat{s}; \mathbf{x}) - \ell(s; \mathbf{x})] \leq \chi_1^2(\alpha)$$

where  $\ell(s; \mathbf{x})$  is value of the log-likelihood given shape parameter  $s$ . The two intervals are returned as elements of a **list** named **wald** and **prof** respectively.

```
> ci = confint(fit)
> ci$wald
      2.5%      97.5%
3.490761 4.418099

> ci$prof
      2.5%      97.5%
3.520495 4.451277
```

You will notice that neither of these intervals contain the value shown in the previous output. However, this simply because they are confidence intervals on  $s'$  and not  $s$ . This can be remedied by adding one to each interval:

```
> ci$wald + 1
      2.5%      97.5%
4.490761 5.418099

> ci$prof + 1
      2.5%      97.5%
4.520495 5.451277
```

The reason for not *correcting* these intervals is that the method mostly exists to feed into other parts of the package, especially the **plot** method.