

# Package ‘barrel’

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**Title** Covariance-Based Ellipses and Annotation Tools for Ordination Plots

**Version** 0.1.0

**Description** Provides tools to visualize ordination results in 'R' by adding covariance-based ellipses, centroids, vectors, and confidence regions to plots created with 'ggplot2'. The package extends the 'vegan' framework and supports Principal Component Analysis (PCA), Redundancy Analysis (RDA), and Non-metric Multidimensional Scaling (NMDS). Ellipses can represent either group dispersion (standard deviation, SD) or centroid precision (standard error, SE), following Wang et al. (2015) <[doi:10.1371/journal.pone.0118537](https://doi.org/10.1371/journal.pone.0118537)>. Robust estimators of covariance are implemented, including the Minimum Covariance Determinant (MCD) method of Hubert et al. (2018) <[doi:10.1002/wics.1421](https://doi.org/10.1002/wics.1421)>. This approach reduces the influence of outliers. barrel is particularly useful for multivariate ecological datasets, promoting reproducible, publication-quality ordination graphics with minimal effort.

**License** MIT + file LICENSE

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autoplot.barrel\_ord    *Autoplot method for barrel\_ord objects*

---

### Description

Generates a ggplot of site scores from a vegan ordination object with optional group ellipses, centroids, and environmental arrows. This method is designed to work with ordination objects prepared using [barrel\\_prepare](#).

### Usage

```
## S3 method for class 'barrel_ord'
autoplot(object, ...)
```

### Arguments

object	An object of class "barrel_ord" (a vegan ordination object with attached meta-data).
...	Additional arguments:
	<b>group</b> Character. Grouping variable in the metadata. (Required)
	<b>data</b> Optional species or environmental data for envfit.
	<b>kind</b> Type of ellipse: "se" or "sd". Default is "se".
	<b>method</b> Covariance method: "classic" or "robust". Default is "classic".
	<b>conf</b> Confidence level for ellipses. Default is 0.95.
	<b>geom_type</b> "polygon" or "path" for ellipse. Default is "polygon".
	<b>show_arrows</b> Logical; whether to show envfit vectors. Default is TRUE.
	<b>show_centroids</b> Logical. Default is FALSE.
	<b>show_ellipses</b> Logical. Default is TRUE.
	<b>show_labels</b> Logical. Label envfit arrows. Default is TRUE.
	<b>p_thresh</b> Numeric. Significance threshold for arrows. Default 0.05.
	<b>alpha</b> Numeric. Transparency of ellipses. Default is 0.5.

### Details

If `geom_type = "polygon"`, group colors are mapped to fill for ellipses. If `geom_type = "path"`, group colors are mapped to color. The grouping variable must be present in the metadata provided to [barrel\\_prepare](#).

### Value

A `ggplot2` object with ordination scores and optional graphical layers.

### See Also

[barrel\\_prepare](#), [stat\\_barrel](#), [rda](#), [metaMDS](#)

### Examples

```
library(vegan)
data(dune)
data(dune.env)
ord <- rda(dune, scale = TRUE)
ord <- barrel_prepare(ord, dune.env)
ggplot2::autoplot(ord,
  group = "Management", data = dune,
  method = "robust", kind = "sd", geom_type = "polygon", show_arrows = TRUE
)
```

---

barrel_label_axes	<i>Add Axis Titles with Method Name and Explained Variance</i>
-------------------	--

---

### Description

This function creates properly formatted axis titles for ordination plots. It uses the ordination method name (e.g., RDA, dbRDA, NMDS) and, when available, the percentage of variance explained by the first two axes.

### Usage

```
barrel_label_axes(ord)
```

### Arguments

`ord` A `vegan` ordination object, such as from `rda()`, `cca()`, `capscale()`, or `metaMDS()`.

### Details

The labels are retrieved using [get\\_ord\\_axis\\_labels](#) and returned as a `ggplot2::labs()` object that can be added to a plot.

**Value**

A `ggplot2::labs()` object with x and y axis titles.

**See Also**

[get\\_ord\\_axis\\_labels](#)

**Examples**

```
library(vegan)
library(ggplot2)
data(dune)
data(dune.env)

# Example with RDA
ord <- rda(dune)
scores_df <- as.data.frame(scores(ord, display = "sites"))
scores_df$Management <- dune.env$Management

ggplot(scores_df, aes(x = PC1, y = PC2, color = Management)) +
  geom_point() +
  barrel_label_axes(ord) +
  theme_minimal() +
  theme(axis.title = element_text(face = "bold", size = 13))
```

---

barrel\_ord\_summary      *Summary Statistics for Ordination Objects*

---

**Description**

Computes adjusted R-squared and percentage of variance explained for constrained ordination methods (e.g., `rda`, `cca`, `capscale`, `dbrda`), or returns the stress value for non-metric multidimensional scaling (`metaMDS`).

**Usage**

```
barrel_ord_summary(ord)
```

**Arguments**

`ord`                    An ordination object of class `rda`, `cca`, `capscale`, `dbrda`, or `metaMDS`.

**Value**

A named list with components:

**method** Class of the ordination object as a character string.

**R2\_adj** Adjusted R-squared (percentage) for constrained ordinations; NA for NMDS.

**axis\_var** Named numeric vector of variance explained by each axis (percentage), if available.

**stress** Stress value for NMDS objects.

**message** Message explaining output, especially for NMDS or missing R2.

**Examples**

```
library(vegan)
data(dune)
data(dune.env)

# PCA (unconstrained ordination)
pca <- rda(dune)
barrel_ord_summary(pca)

# RDA (constrained ordination)
rda_mod <- rda(dune ~ A1 + Moisture, data = dune.env)
barrel_ord_summary(rda_mod)

# NMDS
nmds <- metaMDS(dune, k = 2)
barrel_ord_summary(nmds)

# dbRDA
dbrda_mod <- dbrda(dune ~ A1 + Management, data = dune.env, distance = "bray")
barrel_ord_summary(dbrda_mod)
```

---

barrel\_prepare

*Prepare ordination object for barrel plotting*


---

**Description**

Attaches sample metadata (e.g., grouping variable) to a vegan ordination object and assigns class 'barrel\_ord'.

**Usage**

```
barrel_prepare(ord, metadata)
```

**Arguments**

**ord** A vegan ordination object (e.g., from `rda`, `cca`, `metaMDS`).

**metadata** A data frame of sample metadata. Must have same number of rows as ordination site scores.

**Value**

The ordination object with metadata attached and class "barrel\_ord".

**Examples**

```
library(vegan)
data(dune)
data(dune.env)
ord <- rda(dune, scale = TRUE)
ord_prepared <- barrel_prepare(ord, dune.env)
class(ord_prepared)
```

---

barrel\_stats

*Comprehensive Ordination Visualization Layer*

---

**Description**

Combines ordination ellipses, centroids, environmental arrows, and annotations into a ggplot2 layer.

**Usage**

```
stat_barrel(  
  mapping = NULL,  
  data = NULL,  
  geom = "path",  
  position = "identity",  
  kind = "se",  
  conf = 0.95,  
  method = c("robust", "classic"),  
  show.legend = NA,  
  inherit.aes = TRUE,  
  geom_type = c("path", "polygon"),  
  ...  
)
```

```
stat_barrel_centroid(  
  mapping = NULL,  
  data = NULL,  
  geom = "point",  
  position = "identity",  
  method = c("classic", "robust"),  
  show.legend = NA,  
  inherit.aes = TRUE,  
  shape = 3,  
  ...  
)
```

```

stat_barrel_arrows(
  mapping = NULL,
  data = NULL,
  ord,
  matrix,
  geom = "segment",
  position = "identity",
  labels = TRUE,
  labels.color = "black",
  labels.size = 3,
  labels.fontface = "plain",
  show.significant = FALSE,
  p_thresh = 0.05,
  arrow = grid::arrow(length = grid::unit(0.25, "cm")),
  arrow.color = "grey10",
  arrow.linetype = "solid",
  arrow.size = 0.3,
  labels.max.overlaps = Inf,
  show.legend = NA,
  inherit.aes = TRUE,
  ...
)

compute_envfit_vectors(ord, matrix, p_thresh = 0.05, show.significant = FALSE)

stat_barrel_annotate(
  mapping = NULL,
  data = NULL,
  ord,
  position = "identity",
  show.legend = FALSE,
  inherit.aes = TRUE,
  xpad = 0.05,
  ypad = 0.05,
  hjust = 0,
  vjust = 1,
  ...
)

```

### Arguments

mapping	Set of aesthetic mappings created by <code>aes()</code> .
data	Data frame used for plotting.
geom	Character; geometric object to use for ellipses, either "path" or "polygon".
position	Position adjustment for <code>ggplot2</code> layers (default "identity").
kind	Character; type of ellipse: "se" (standard error), "sd" (dispersion), or "ci" (confidence interval).

<code>conf</code>	Numeric; confidence level for ellipses (default 0.95).
<code>method</code>	Character; covariance estimation method: "classic" or "robust".
<code>show.legend</code>	Logical; whether to show legends (default NA).
<code>inherit.aes</code>	Logical; whether to inherit aesthetics (default TRUE).
<code>geom_type</code>	Character; geometric object to use for ellipses, either "path" or "polygon".
<code>...</code>	Additional parameters passed to underlying geoms or stats.
<code>shape</code>	Integer; shape code for centroid points (default 3).
<code>ord</code>	Ordination object from <code>vegan</code> , e.g. <code>rda</code> , <code>cca</code> , <code>dbrda</code> , or <code>metaMDS</code> .
<code>matrix</code>	Optional data frame of environmental variables for arrows.
<code>labels</code>	Logical; whether to show labels on environmental arrows (default TRUE).
<code>labels.color</code>	Color of arrow labels (default "black").
<code>labels.size</code>	Numeric size of arrow labels (default 3).
<code>labels.fontface</code>	Font face of arrow labels (default "plain").
<code>show.significant</code>	Logical; whether to show only significant arrows (default FALSE).
<code>p_thresh</code>	Numeric; p-value threshold for significance filtering (default 0.05).
<code>arrow</code>	A grid arrow object controlling arrow appearance (default created by <code>grid::arrow()</code> ).
<code>arrow.color</code>	Color of arrows (default "grey10").
<code>arrow.linetype</code>	Line type of arrows (default "solid").
<code>arrow.size</code>	Numeric line width of arrows (default 0.3).
<code>labels.max.overlaps</code>	Maximum number of labels in the same space (default "Inf").
<code>xpad</code>	Numeric; horizontal padding for annotation text relative to x-axis range (default 0.05).
<code>ypad</code>	Numeric; vertical padding for annotation text relative to y-axis range (default 0.05).
<code>hjust</code>	Numeric; horizontal justification of annotation text (default 0).
<code>vjust</code>	Numeric; vertical justification of annotation text (default 1).

## Details

### Comprehensive Ordination Visualization Layer

This set of `ggplot2` stats draws ellipses around groups, centroids, environmental arrows, and adds adjusted  $R^2$  or stress annotation for ordination objects from `vegan`.

## Value

A `ggplot2` layer combining ellipses, centroids, arrows, and annotations.

## Examples

```
library(ggplot2)
library(vegan)
library(robustbase)
data(dune)
data(dune.env)

pca <- vegan::rda(dune, scale = TRUE)
scores <- as.data.frame(vegan::scores(pca, display = "sites"))
scores$Management <- dune.env$Management

ggplot(scores, aes(PC1, PC2, group = Management, fill = Management)) +
  stat_barrel(
    method = "classic", kind = "se", conf = 0.95, geom_type = "polygon",
    alpha = 0.4, color = "black"
  ) +
  stat_barrel_centroid(method = "classic", shape = 3) +
  stat_barrel_arrows(
    ord = pca, matrix = dune,
    labels = TRUE, labels.color = "blue",
    arrow.color = "darkred", arrow.linetype = "solid",
    labels.fontface = "bold", show.significant = TRUE,
    labels.max.overlaps = Inf,
  ) +
  stat_barrel_annotate(ord = pca, xpad = 0.05, ypad = 0.05) +
  geom_point(aes(color = Management)) +
  theme_minimal()
```

---

get\_ord\_axis\_labels     *Internal function to get axis labels for vegan ordination objects*

---

## Description

This function infers the ordination method used and returns proper axis labels including percentage of explained variance when applicable.

## Usage

```
get_ord_axis_labels(ord)
```

## Arguments

ord                    A vegan ordination object.

## Value

A list with one element label, a character vector for axis labels. #' @examples library(vegan) data(dune) data(dune.env) ord\_pca <- rda(dune) get\_ord\_axis\_labels(ord\_pca)

---

ord\_compute\_ellipse    *Compute coordinates for an ordination ellipse*

---

### Description

Calculates ellipse coordinates based on a covariance matrix and center. Supports confidence ellipses (standard error, "se") or dispersion ellipses ("sd").

### Usage

```
ord_compute_ellipse(  
  cov,  
  center = c(0, 0),  
  kind = "se",  
  conf = 0.95,  
  npoints = 100,  
  n = NULL  
)
```

### Arguments

cov	Numeric matrix (2x2) covariance matrix.
center	Numeric vector of length 2 specifying the ellipse center coordinates.
kind	Character string specifying the type of ellipse: either "se" for standard error/confidence ellipse or "sd" for standard deviation dispersion ellipse.
conf	Numeric confidence level or coverage (default 0.95).
npoints	Integer number of points to generate along ellipse perimeter (default 100).
n	Numeric sample size; <b>required</b> if kind = "se".

### Value

A numeric matrix with two columns representing x and y coordinates of the ellipse.

### Examples

```
cov_mat <- matrix(c(1, 0, 0, 1), 2, 2)  
center <- c(0, 0)  
ell_coords <- ord_compute_ellipse(cov_mat, center, kind = "se", conf = 0.95, n = 10)  
plot(ell_coords, type = "l")
```

---

ord\_ellipse\_group      *Compute Ellipse Coordinates for a Single Group*

---

### Description

Calculates ellipse coordinates for one group in ordination scores with robust or classic covariance.

### Usage

```
ord_ellipse_group(  
  scores,  
  group_var,  
  group_name,  
  axis1,  
  axis2,  
  kind = "se",  
  conf = 0.95,  
  method = "classic"  
)
```

### Arguments

scores	Data frame of ordination scores.
group_var	Name of grouping column.
group_name	Name of the group to calculate ellipse.
axis1	Name of first axis column.
axis2	Name of second axis column.
kind	Type of ellipse: "se" or "sd".
conf	Confidence level.
method	Covariance method: "classic" or "robust".

### Details

Compute ellipse coordinates for a specific group in ordination scores

Calculates ellipse coordinates for one group from ordination scores, supporting classical or robust covariance estimation.

### Value

Data frame of ellipse coordinates with group label.

A data frame with ellipse coordinates and group label.

**Examples**

```

library(vegan)
data(dune)
data(dune.env)
pca <- rda(dune, scale = TRUE)
scores <- as.data.frame(scores(pca, display = "sites"))
scores$Group <- dune.env$Management
ell <- ord_ellipse_group(scores, "Group", "BF", "PC1", "PC2", kind = "se", method = "classic")
plot(ell$PC1, ell$PC2, type = "l")

```

---

ord\_ellipse\_groups      *Compute Ellipse Coordinates for All Groups*

---

**Description**

Calculates ellipse coordinates for all groups in ordination scores.

**Usage**

```

ord_ellipse_groups(
  scores,
  group_var,
  axis1,
  axis2,
  kind = "se",
  conf = 0.95,
  method = "classic"
)

```

**Arguments**

scores	Data frame of ordination scores.
group_var	Name of grouping column.
axis1	Name of first axis column.
axis2	Name of second axis column.
kind	Type of ellipse: "se" or "sd".
conf	Confidence level.
method	Covariance method: "classic" or "robust".

**Details**

Compute ellipse coordinates for all groups in ordination scores

Calculates ellipse coordinates for all groups in ordination scores, supports classic and robust covariance estimation.

**Value**

Data frame of ellipse coordinates with group labels.

---

ord\_extract\_centroids *Extract Group Centroids from Ordination Scores*

---

**Description**

Computes centroids per group using classic mean or robust methods.

**Usage**

```
ord_extract_centroids(  
  scores,  
  group_var,  
  axis1,  
  axis2,  
  method = c("classic", "robust")  
)
```

**Arguments**

scores	Data frame of ordination scores.
group_var	Name of grouping column.
axis1	Name of first axis column.
axis2	Name of second axis column.
method	Centroid method: "classic" or "robust".

**Details**

Extract centroids of groups from ordination scores with classic or robust method

Computes the centroid coordinates for each group using either the classical mean or robust minimum covariance determinant.

**Value**

Data frame with group centroids.

---

ord_extract_cov	<i>Extract covariance matrix from ordination scores with optional robust estimation</i>
-----------------	---

---

**Description**

Computes the covariance matrix of ordination scores, optionally using robust estimation.

**Usage**

```
ord_extract_cov(
  scores,
  axis1,
  axis2,
  weights = NULL,
  method = c("classic", "robust")
)
```

**Arguments**

scores	Data frame of ordination scores.
axis1	Name of first axis column.
axis2	Name of second axis column.
weights	Optional numeric vector of weights.
method	Covariance method: "classic" or "robust".

**Value**

2x2 covariance matrix.

---

ord_vectors	<i>Extract significant environmental vectors from vegan ordination object</i>
-------------	---

---

**Description**

Performs an envfit analysis and returns environmental vectors with p-values, filtered by significance or unfiltered.

**Usage**

```
ord_vectors(
  ord,
  data,
  p_thresh = 0.05,
  filter = c("significant", "nonsignificant", "all")
)
```

**Arguments**

<code>ord</code>	Vegan ordination object (e.g., <code>rda</code> , <code>cca</code> ).
<code>data</code>	Environmental variables data frame used for <code>envfit</code> .
<code>p_thresh</code>	P-value threshold to determine significance (default 0.05).
<code>filter</code>	Character; one of "significant" (default), "nonsignificant", or "all".

**Value**

Data frame of vectors with scores, p-values, and labels.

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