

## BioNumerics Tutorial:

# Importing data in a database with levels

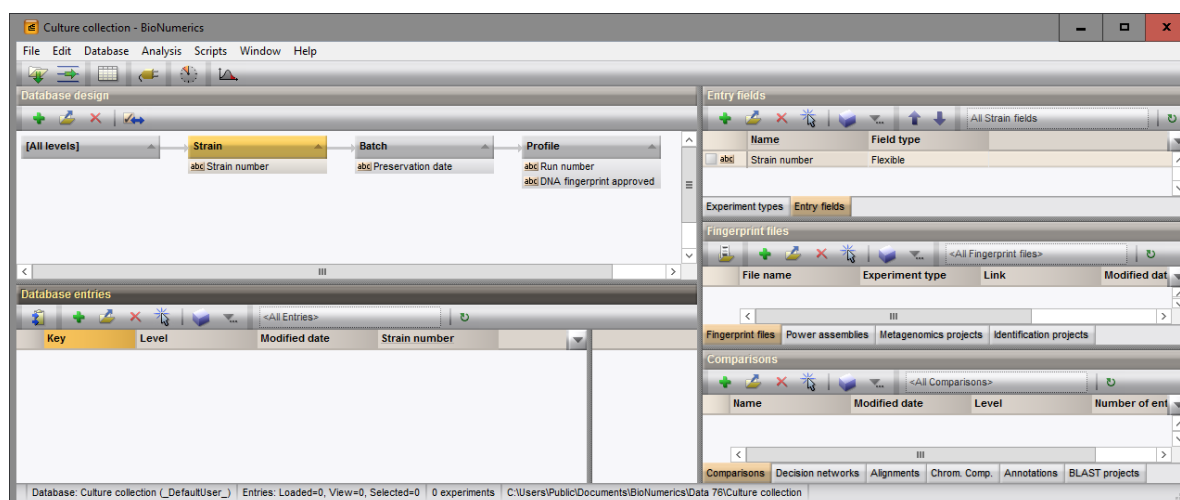
## 1 Aim

In this tutorial you will learn how to import data in a BioNumerics database with levels and how to replicate and summarize level-specific information and experimental data to other levels.

## 2 Preparing a sample database

1. Create a new database and define the levels as described in the tutorial: "Setting up a BioNumerics database with levels".

Three hierarchical levels should now be present in your example database (see Figure 1):



**Figure 1:** The *Main* window with levels defined.

1. **Strain:** This level will contain all strains. The **Strain number** is defined and is replicated to the **Batch** and **Profile** levels.
2. **Batch:** This level will information about the batches. A batch is always prepared from a single strain. From any given strain in the database, multiple batches can be prepared. The **Preservation date** field has been defined at this level.
3. **Profile:** The **Run number** and **DNA fingerprint approved** fields has been defined at this level and two approved states have been specified: **Yes** and **No**. The **Run number** is replicated to the **Batch** level.

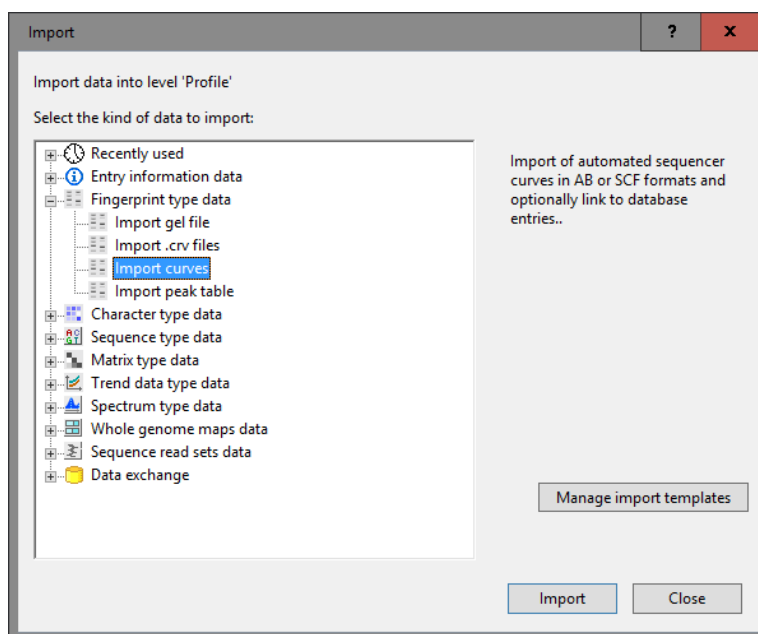
As an exercise, we will import a set of capillary electrophoresis profiles (= electropherograms) produced by a Beckman automated sequencer (.SCF files) in this database.

2. The curves can be downloaded from the Applied Maths website: go to <http://www.applied-maths.com/download/sample-data> and click on "Data set leveled database". When the download is complete, unzip the file.

### 3 Importing data

When importing data (descriptive information and/or experimental data) in a database with levels, it is important to highlight the corresponding level first. Typically, information will most often be imported at the deepest child level (i.e. **Profile** in our example database).

1. Make sure the **Profile** level is selected in the *Database design* panel and select **File > Import...** (📁, **Ctrl+I**).
2. Select **Fingerprint type data > Import curves** and press **<Import>** (see Figure 2).



**Figure 2:** Import tree.

3. Browse to the downloaded and unzipped example data folder containing the DNA fingerprints. Select all 56 .SCF files in this folder and press **<Open>**.

The files are displayed in the *Input* wizard page and the default suggested **Fingerprint file name** is the folder name.

4. Press **<Next>**.

The *Import rules* dialog box lists the information present in the selected files as **Source**, their linked **Source type** and the **Destination** component they are associated with (currently all set to **<None>**).

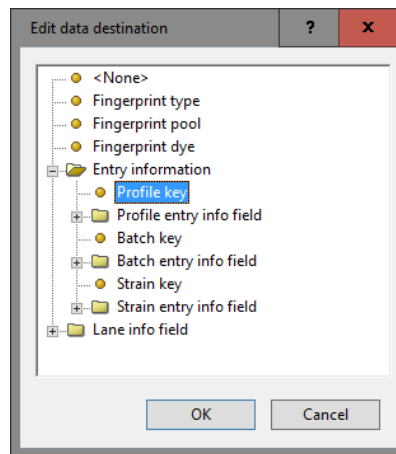
5. Select **Curve dye** from the list, select **<Edit destination>** and select **Fingerprint dye** as corresponding field. Press **<OK>**.

We will now link the file names to the **Key** field of the **Profile** level:

6. Double-click on the **File** row available in the grid or select the row and press **<Edit Destination>**.
7. Select **Profile key** in the *Edit data destination* dialog box (see Figure 3) and press **<OK>**.

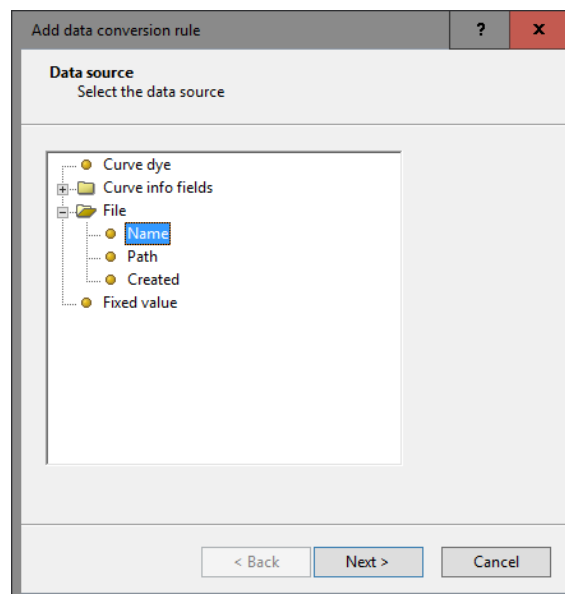
We will now link part of the file names to the **Key** fields of the **Batch** and **Strain** levels:

8. Visualize the advanced options for the *Import template* dialog box by clicking on the check box next to **Show advanced options**.
9. Press **<Add rule>** to open the *Add data conversion rule* wizard.



**Figure 3:** Link to *Profile key*.

10. In the first page of the *Add data conversion rule* wizard select **File** > **Name** and press <Next> (see Figure 4).

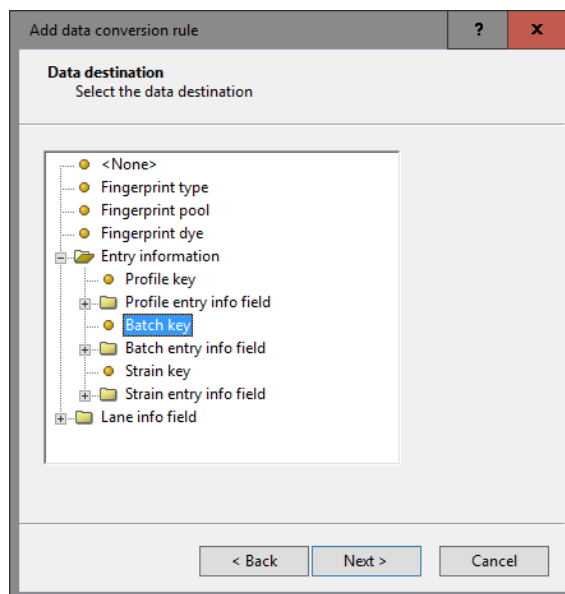


**Figure 4:** Link *File name*.

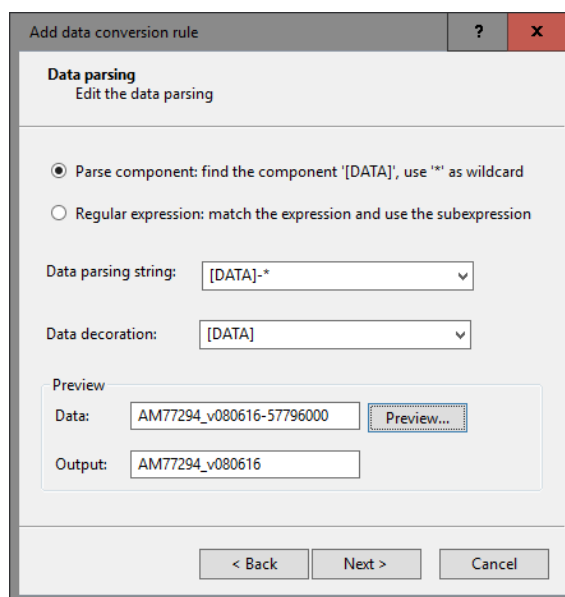
11. In the second page of the *Add data conversion rule* wizard, select **Batch key** and press <Next> (see Figure 5).
12. In the *Data parsing* dialog box, fill in following data parsing string: "[DATA]-\*". Press the <Preview> button (see Figure 6).

This parsing string will only retain the text before the "-" and will store the text in the **Batch Key** field.

13. When the information is parsed correctly press <Next> and <Finish>.
14. Press <Add rule> again to open the *Add data conversion rule* wizard.
15. In the first page of the *Add data conversion rule* wizard select **File** > **Name** and press <Next>.
16. In the second page of the *Add data conversion rule* wizard, select **Strain key** and press <Next> (see Figure 7).



**Figure 5:** Link to *Batch key*.



**Figure 6:** Parsing string.

17. In the *Data parsing* dialog box, fill in following data parsing string: "[DATA]\*". Press the **<Preview>** button (see Figure 8).

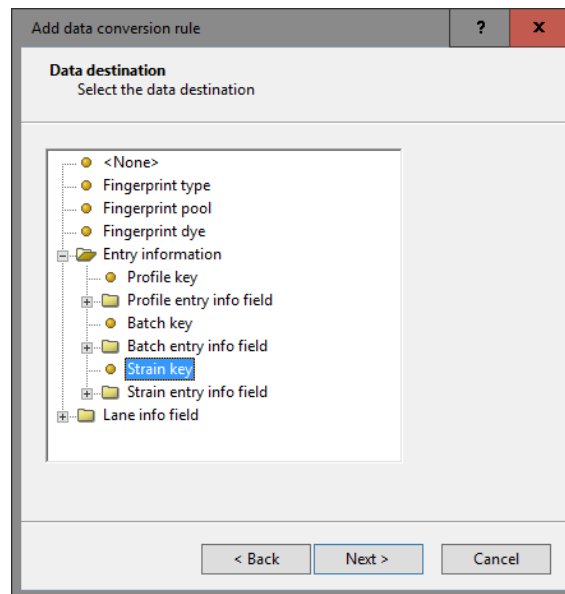
This parsing string will only retain the text before the "\_" and will store the text in the *Strain key* field.

18. When the information is parsed correctly press **<Next>** and **<Finish>**.

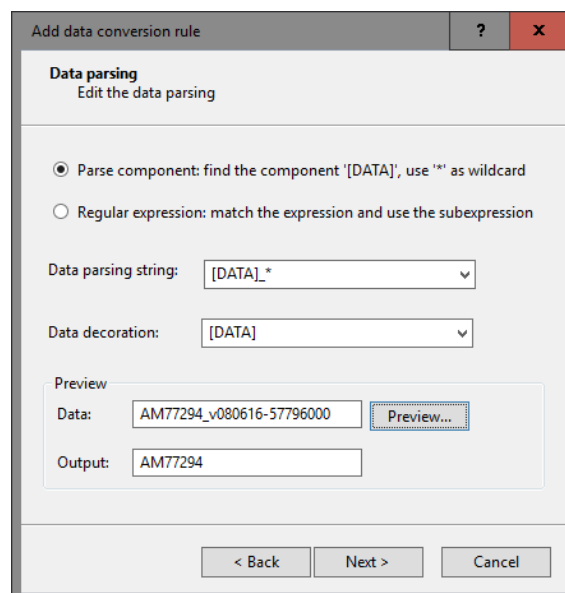
The grid is updated and should now look like Figure 9.

19. In the *Import template* dialog box, press **<Preview>** and verify the preview of the import.

Extra information, such as the profile *Run number* and the batch *Preservation date* can also be parsed from



**Figure 7:** Link to *Strain key*.



**Figure 8:** Parsing string.

the file names.

20. Press **<Add rule>** again to open the *Add data conversion rule* wizard. Select **File > Name** and press **<Next>**. Select **Run number** under **Profile entry info field** and press **<Next>**. Fill in following data parsing string: **"\*-[DATA]"** (see Figure 10). Press the **<Preview>** button. Press **<Next>** and **<Finish>**.
21. Press **<Add rule>** again to open the *Add data conversion rule* wizard. Select **File > Name** and press **<Next>**. Select **Preservation date** under **Batch entry info field** and press **<Next>**. Fill in following data parsing string: **"\*v[DATA]-"** (see Figure 11). Press the **<Preview>** button. Press **<Next>** and **<Finish>**.

The grid is updated and should now look like Figure 12.

22. In the *Import template* dialog box, press **<Preview>** and verify the preview of the import (see Figure 13).

**Import template** ? X

**Import rules**  
Select import sources and the database destinations

Source type	Source	Destination type	Destination	Parsing	Default	Rank
Curve dye	Curve dye	Fingerprint type	Fingerprint type	<Copy>	No	1
Curve info fields	Lane	<None>	<None>			
Curve info fields	Sample	<None>	<None>			
Curve info fields	Comment	<None>	<None>			
File	Name	Entry information	Profile key	<Copy>	No	1
File	Name	Entry information	Batch key	<Parse>	No	1
File	Name	Entry information	Strain key	<Parse>	No	1

☒ Show advanced options

**Figure 9:** Import and parsing rules.

**Add data conversion rule** ? X

**Data parsing**  
Edit the data parsing

☒ Parse component: find the component '[DATA]', use '\*' as wildcard  
☐ Regular expression: match the expression and use the subexpression

Data parsing string:

Data decoration:

Preview

Data:

Output:

**Figure 10:** Parsing string for the *Run number*.

23. Press **<Next>** to go to the next step.

In the example data set, channel 1 contains the size standard and channel 4 represents the actual samples.

24. Make sure **1** is selected as reference dye and uncheck the dyes **2** and **3** to prevent the import of these channels (see Figure 14).

25. Press **<Next>** and **<Finish>**.

**Add data conversion rule**

**Data parsing**  
Edit the data parsing

☒ Parse component: find the component '[DATA]', use '\*' as wildcard  
☐ Regular expression: match the expression and use the subexpression

Data parsing string:

Data decoration:

Preview  
Data:    
Output:

**Figure 11:** Parsing string for the *Preservation date*.

**Import template**

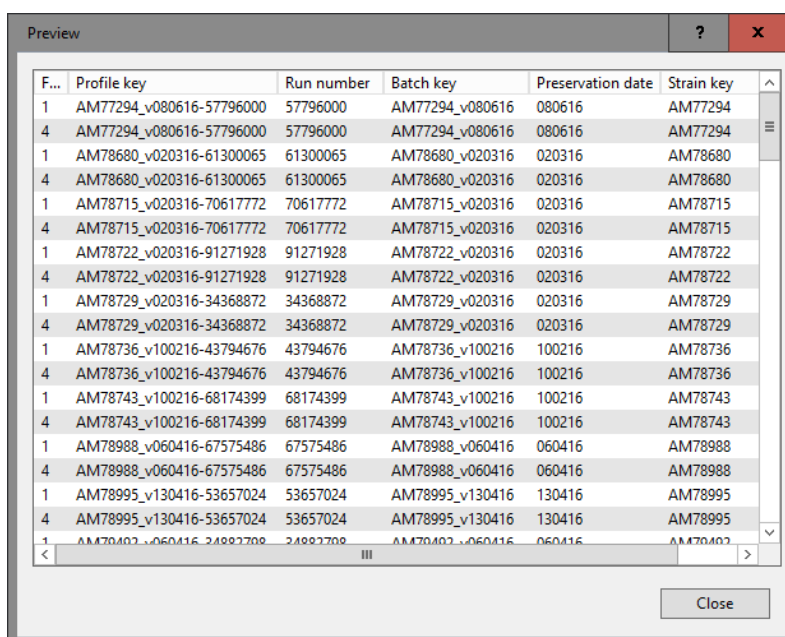
**Import rules**  
Select import sources and the database destinations

Source type	Source	Destination type	Destination	Parsing	Default	R
Curve dye	Curve dye	Fingerprint dye	Fingerprint dye	<Copy>	No	1
Curve info fields	Lane	<None>	<None>			
Curve info fields	Sample	<None>	<None>			
Curve info fields	Comment	<None>	<None>			
<b>File</b>	<b>Name</b>	<b>Entry information</b>	<b>Profile key</b>	<b>&lt;Copy&gt;</b>	<b>No</b>	<b>1</b>
File	Name	Entry information	Batch key	<Parse>	No	1
File	Name	Entry information	Strain key	<Parse>	No	1
File	Name	Entry information : Profile entry info field	Run number	<Parse>	No	1
File	Name	Entry information : Batch entry info field	Preservation date	<Parse>	No	1

☒ Show advanced options

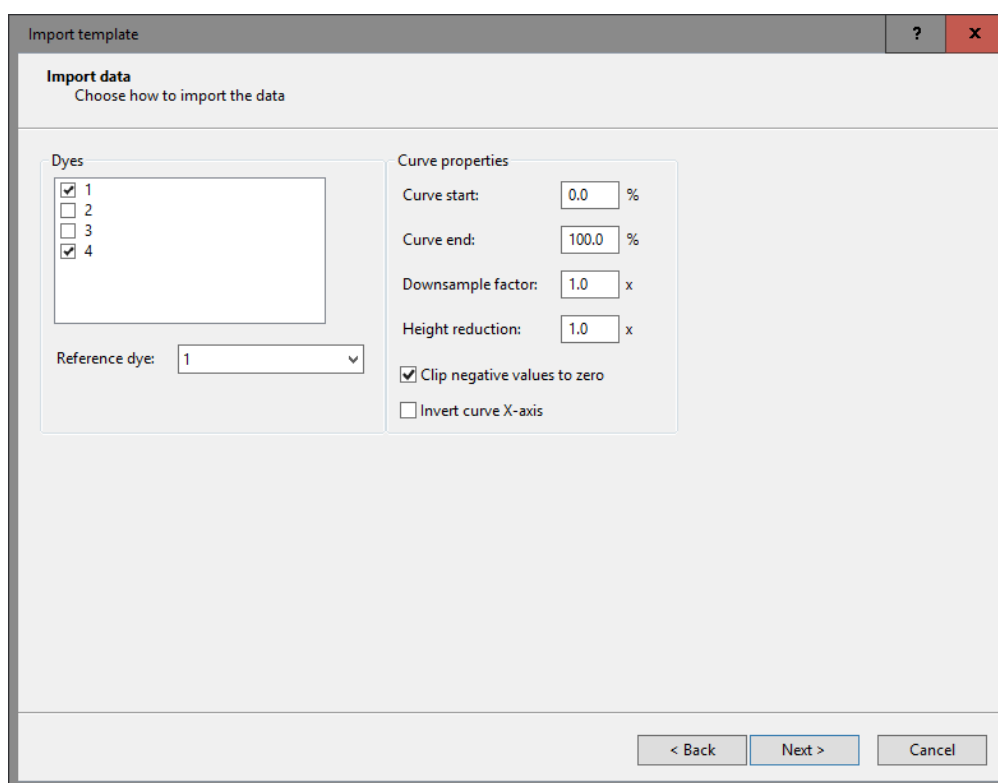
**Figure 12:** Import and parsing rules.

26. Specify a template name, e.g. **Import AB curve files** and press **<OK>**.
27. Make sure the newly created template is selected and press **<Next>** (see Figure 15).
28. Specify an experiment name e.g. **AFLP** (see Figure 16), press **<OK>** and confirm the action.
29. Specify an OD range of **65536** gray values (= 16-bit) and press **<OK>**.



F...	Profile key	Run number	Batch key	Preservation date	Strain key
1	AM77294_v080616-57796000	57796000	AM77294_v080616	080616	AM77294
4	AM77294_v080616-57796000	57796000	AM77294_v080616	080616	AM77294
1	AM78680_v020316-61300065	61300065	AM78680_v020316	020316	AM78680
4	AM78680_v020316-61300065	61300065	AM78680_v020316	020316	AM78680
1	AM78715_v020316-70617772	70617772	AM78715_v020316	020316	AM78715
4	AM78715_v020316-70617772	70617772	AM78715_v020316	020316	AM78715
1	AM78722_v020316-91271928	91271928	AM78722_v020316	020316	AM78722
4	AM78722_v020316-91271928	91271928	AM78722_v020316	020316	AM78722
1	AM78729_v020316-34368872	34368872	AM78729_v020316	020316	AM78729
4	AM78729_v020316-34368872	34368872	AM78729_v020316	020316	AM78729
1	AM78736_v100216-43794676	43794676	AM78736_v100216	100216	AM78736
4	AM78736_v100216-43794676	43794676	AM78736_v100216	100216	AM78736
1	AM78743_v100216-68174399	68174399	AM78743_v100216	100216	AM78743
4	AM78743_v100216-68174399	68174399	AM78743_v100216	100216	AM78743
1	AM78988_v060416-67575486	67575486	AM78988_v060416	060416	AM78988
4	AM78988_v060416-67575486	67575486	AM78988_v060416	060416	AM78988
1	AM78995_v130416-53657024	53657024	AM78995_v130416	130416	AM78995
4	AM78995_v130416-53657024	53657024	AM78995_v130416	130416	AM78995
1	AM70402_v060416-24822708	24822708	AM70402_v060416	060416	AM70402

Figure 13: Preview.



**Import template**

**Import data**  
Choose how to import the data

**Dyes**

☒ 1  
☐ 2  
☐ 3  
☒ 4

Reference dye: 1

**Curve properties**

Curve start: 0.0 %  
 Curve end: 100.0 %  
 Downsample factor: 1.0 x  
 Height reduction: 1.0 x

☒ Clip negative values to zero  
☐ Invert curve X-axis

< Back   Next >   Cancel

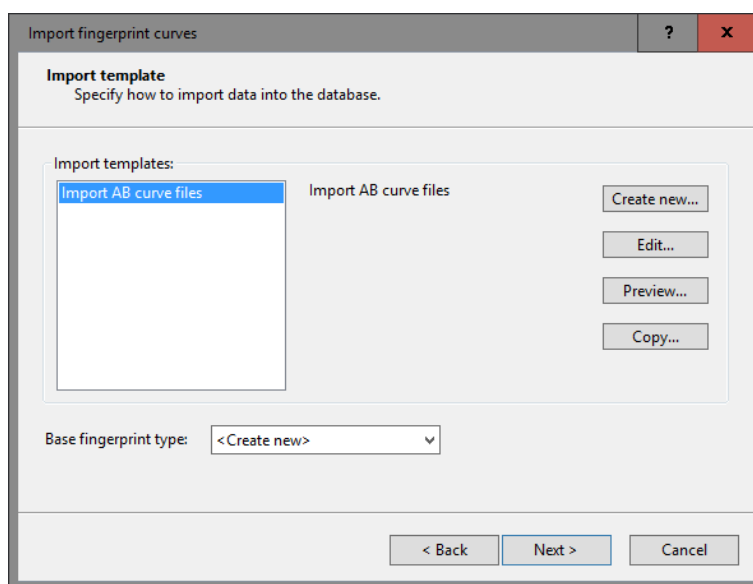
Figure 14: Import data.

A fingerprint type needs to be present in the database for each dye. The names of these fingerprint types are composed of the base fingerprint type name, followed by the dye name. A new dialog box pops up, listing all missing fingerprint types (see Figure 18).

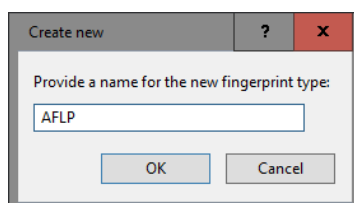
30. Confirm the creation of the two missing experiments in the database.

31. Press **<Next>** to confirm the creation of the new entries in each level (see Figure 19).

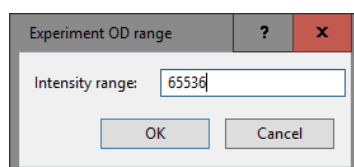




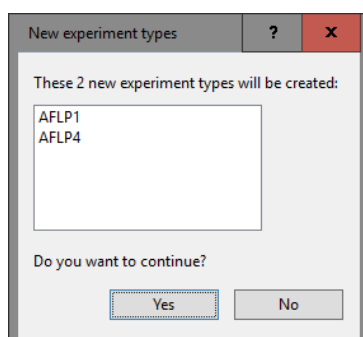
**Figure 15:** Import template and experiment.



**Figure 16:** Base fingerprint type experiment.



**Figure 17:** OD range.



**Figure 18:** Two new experiments.

32. Make sure *Open curve preprocessing window* is checked in the last step and press *<Finish>*.

For each dye checked in the *Dyes panel* of the *Import data* dialog box, a new fingerprint file is created,

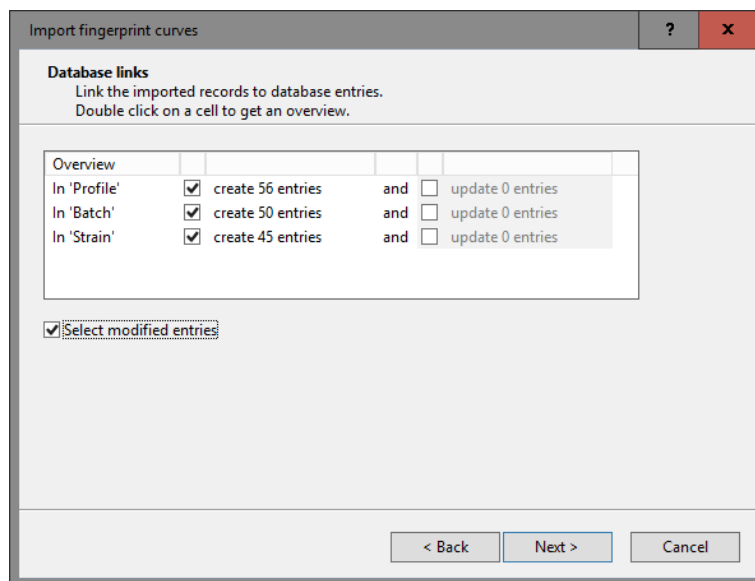


Figure 19: Database entries per level.

composed of the file name specified and the name of the dye (e.g. DNA fingerprints\_1). These files are displayed in the *Fingerprint files* panel. The reference file is shown in the **Link** column. Double-clicking on a fingerprint file opens the *Fingerprint* window.

In the **Profile** level, 56 entries are added to the *Database entries* panel (see Figure 20). The **Run number** information is parsed from the file names and the **DNA fingerprint approved** state is default set to *No*. The **Strain number** is replicated from the **Strain** level. The imported fingerprint lanes are linked to new entries in the database and to the corresponding fingerprint "dye" type (**AFLP1** and **AFLP4**). The fingerprint type experiments are displayed in the *Experiment types* panel.

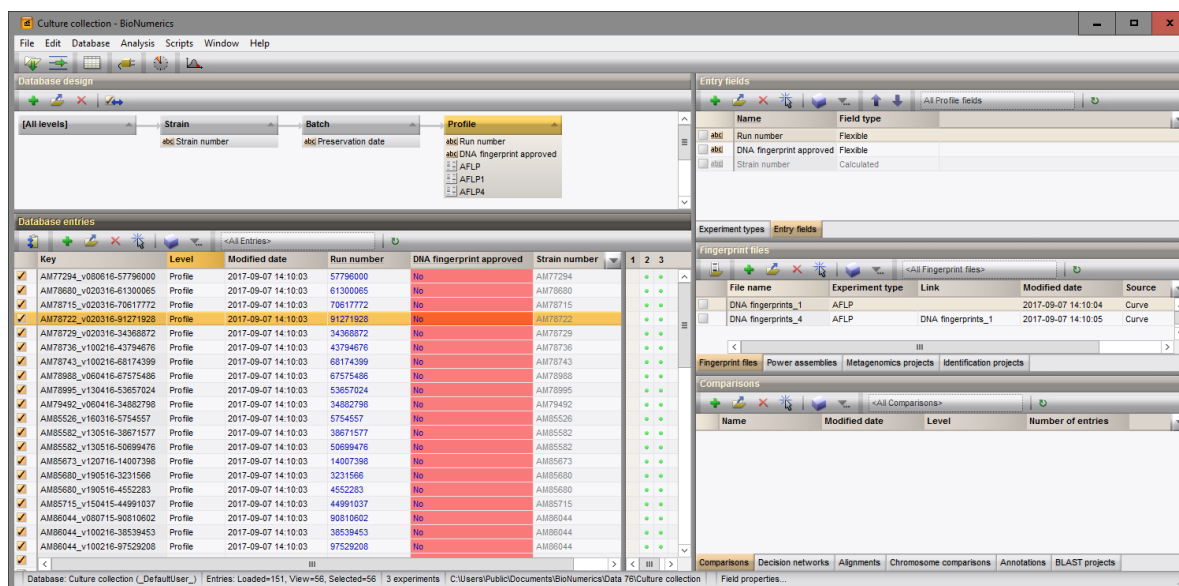


Figure 20: The Main window after import of the curves: **Profile** level.

In the **Batch** level, 50 entries are present in the *Database entries* panel (see Figure 21). The **Preservation date** information is parsed from the file names and the **Run numbers** are summarized from the **Profile** level. The **Strain number** is replicated from the **Strain** level.

In the **Strain** level, 45 entries are added to the *Database entries* panel.

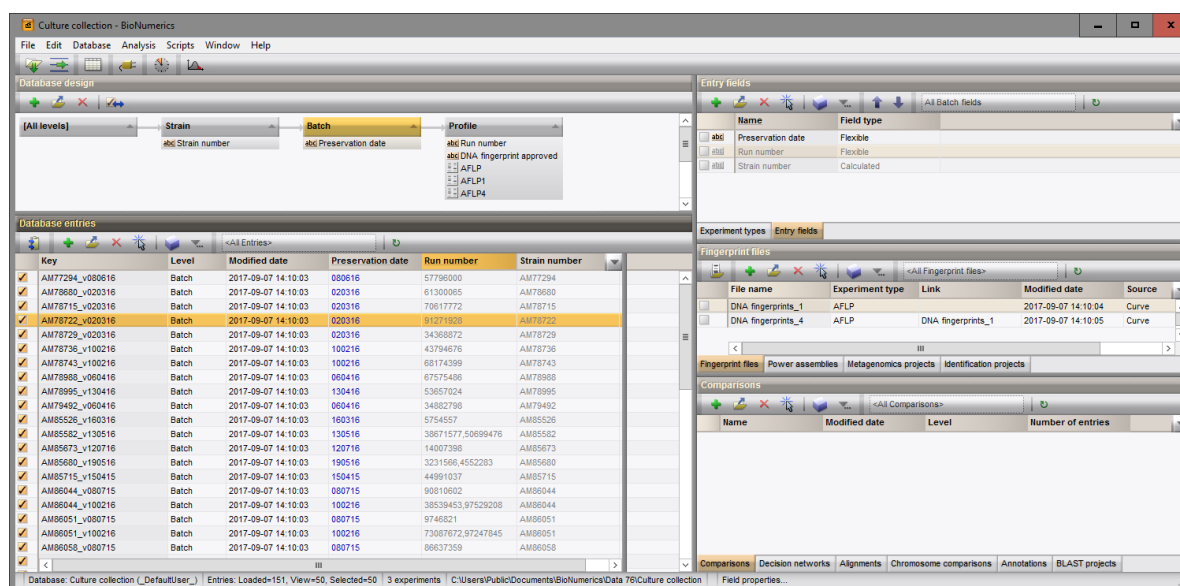


Figure 21: The *Main* window after import of the curves: *Batch* level.

## 4 Processing data

When the option *Open curve preprocessing window* was checked in the last step of the import routine, the *Fingerprint curve processing* window opens when pressing the **<Finish>** button. The two channels from the run are automatically loaded and displayed in the *Fingerprint curve processing* window.



The *Fingerprint curve processing* window can also be called from the *Main* window by highlighting one of the channels in the *Fingerprint files* panel and select **Open fingerprint data...** (🖨️). Alternatively, you can first open the *Fingerprint* window with **Edit > Open highlighted object...** (🖨️, **Enter**) and then select **File > Edit fingerprint data...** (🖨️).

1. Click on the 👁 icon left of the **AFLP4** channel in the *Channels* panel.

The data channel is now hidden from the view and its icon is displayed as 🚫.

2. Use the zoom sliders on the left and on top to optimize the display of the fingerprint curves.

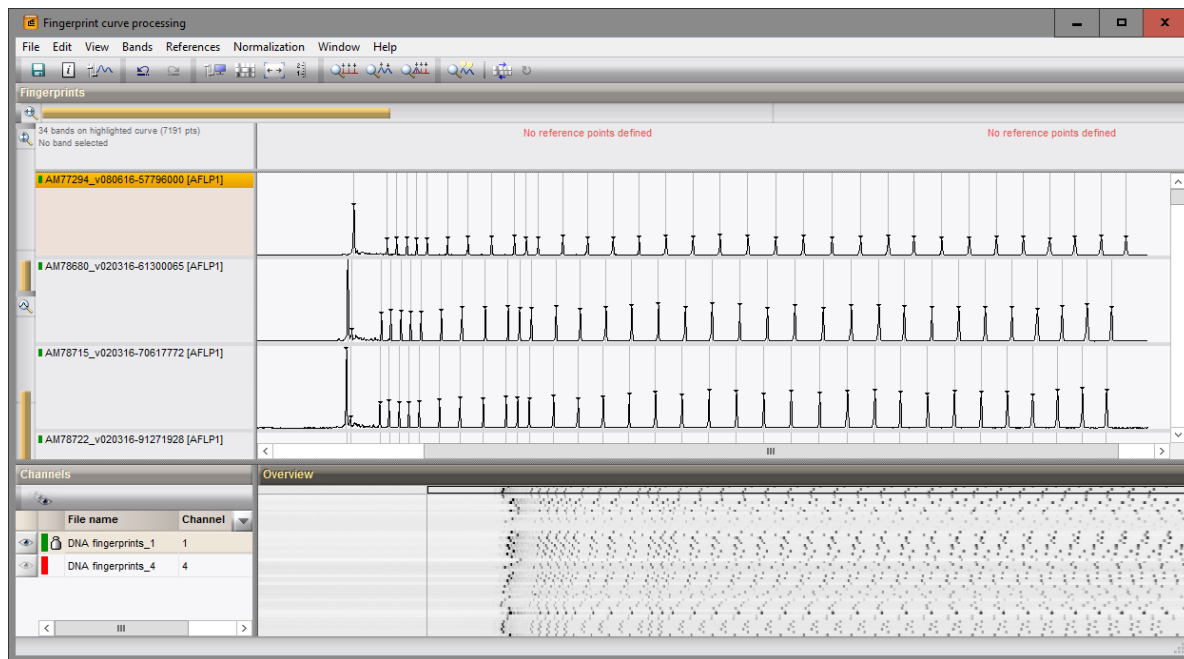
Since the raw chromatogram files have not undergone any preprocessing, normalization will have to be performed. This requires a *reference system* to be defined, based upon the marker peaks available in the reference dye.

3. Make sure the reference dye is the only dye visible in the upper panel (see Figure 22).
4. Select **Bands > Search reference bands...** (🔍, **Ctrl+F**) to call the *Search reference bands* dialog box.
5. Specify a peak detection **OD range** of **2** (in %) and a peak detection **Curve range** of **5** (in %). Press **<OK>**.

The bands that fall within the specified criteria are marked with a solid line at the band's position (see Figure 22).

6. Select a suitable lane and then select **References > Define size standard...**

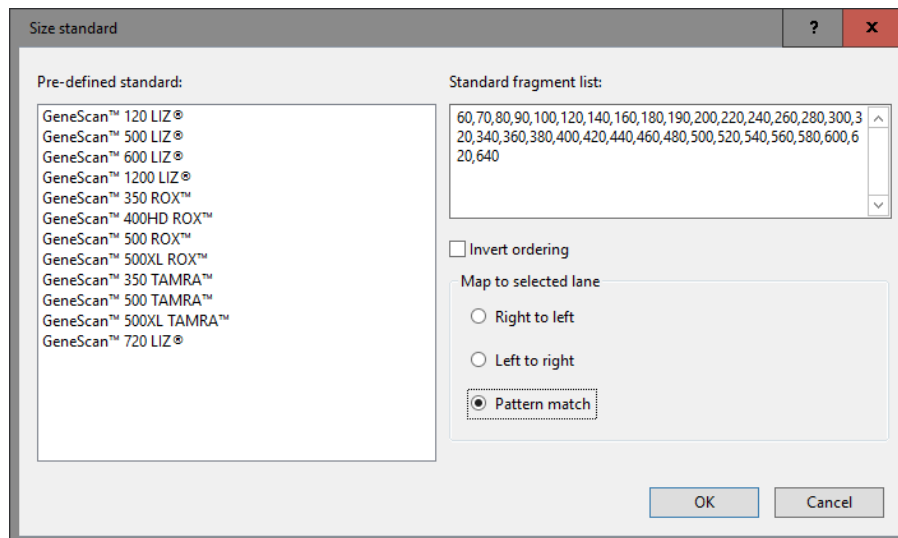
This will display the *Size standard* dialog box, from which a size marker can be selected. In the example curve files, the size standard is not listed. The molecular weights of the reference can be copied from the



**Figure 22:** The *Fingerprint curve processing* window only displaying the reference dye.

text file `SizeMarker.txt`.

7. Paste the copied weights to the *List* panel and check **Pattern match** (see Figure 23). Press <OK> twice.




**Figure 23:** Define size standard.

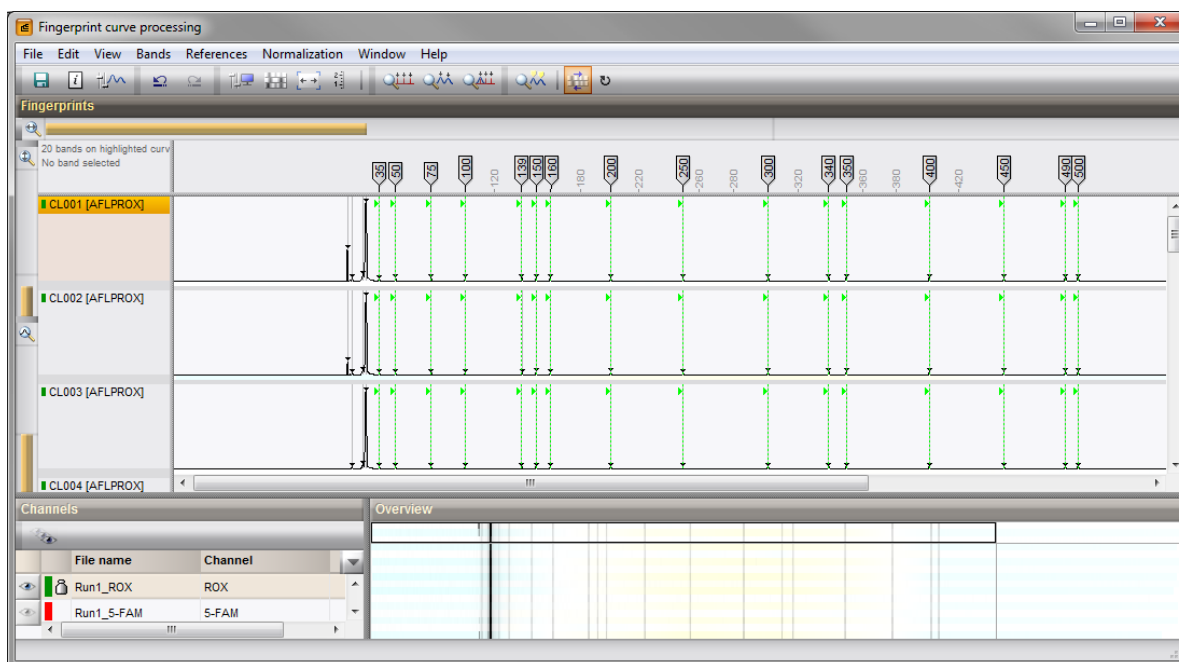
8. Save the data to the database with **File > Save** (📁, **Ctrl+S**) and confirm.

The software will automatically create the reference system and calibration curve for each of the fingerprint types. Since this allows the calculation of metrics information, a metrics scale now becomes available in the upper part of the *Fingerprints* panel.


Normalization is achieved by assigning bands in the reference channel to external reference positions.

9. To normalize a complete run at once, select **Normalization > Auto assign reference positions (all lanes)...** (🔍, **Ctrl+A**), leave all settings unaltered and press <OK>.


10. When the assignment of the marker bands to reference positions is made, the data can be shown in normalized mode with **Normalization > Show normalized view** (, **Shift+N**).



**Figure 24:** Normalized view - reference channel.

11. Click on the  icon left of the **AFLP4** and **AFLP1** channels in the **Channels** panel.

The data channel is now shown and the reference channel is hidden from the view.

12. Select **Bands > Search data bands...** (, **Ctrl+Shift+F**) to call the *Search data bands* dialog box.
13. Specify a peak detection **OD range** of **2** (in %) and a peak detection **Curve range** of **1** (in %). Check **Filter by fragment length**, specify a **Minimum fragment length** of **35** and press **<OK>**.
14. Optionally the *Search data bands* dialog box can be called again to optimize the band search settings.



If you want to calculate the similarity between the AFLP4 data curves in the *Comparison* window using a curve based coefficient (e.g. **Pearson correlation**), the search for bands can be skipped in the data channel.

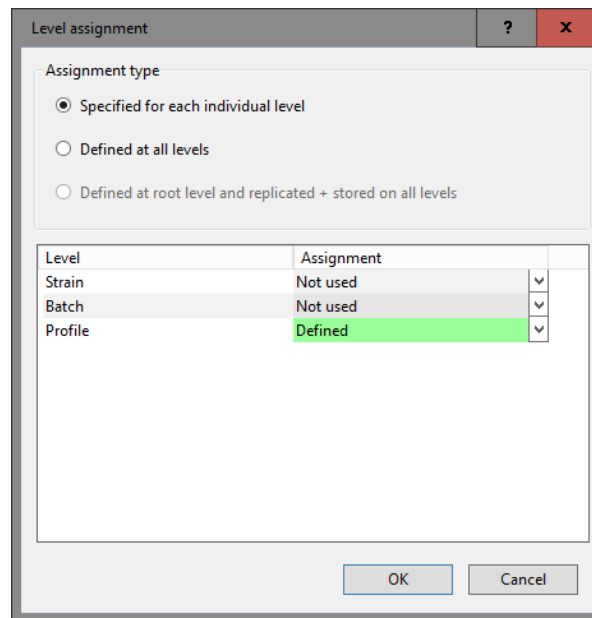
15. Save the changes and close the *Fingerprint curve processing* window.

## 5 Summarizing data

Similar to information fields (see tutorial "Setting up a BioNumerics database with levels") experiment types can also be defined at a specific database levels and replicated over other levels if desired.

In this example, the profiles are linked to the fingerprint experiment type **AFLP4** in the **Profile** level. Replicated measurements are present and since we want to pick a representative pattern and use it at the **Batch** and **Strain** levels, we need to replicate the experiment type at these levels:

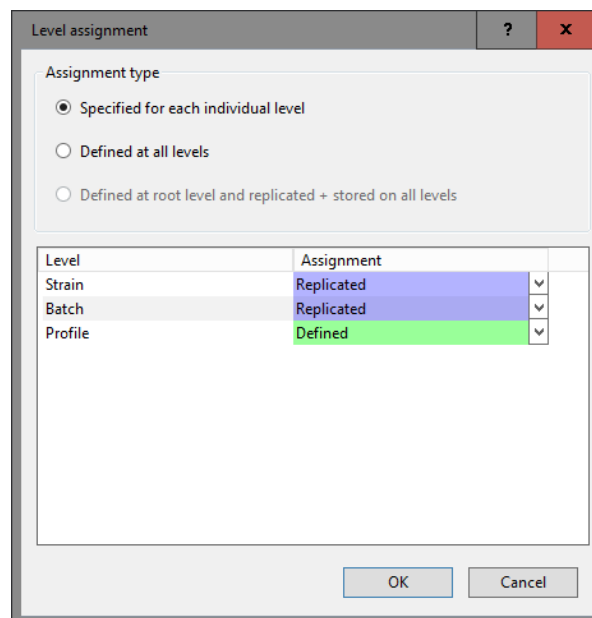
1. Double-click on **AFLP4** in the *Experiment types* panel to open the *Fingerprint type* window for this experiment type.
2. Select **Settings > Level assignment...** to show the *Level assignment* dialog box (see Figure 25).



Level	Assignment
Strain	Not used
Batch	Not used
Profile	Defined

**Figure 25:** The initial level assignment settings for *AFLP4*.

3. Use the corresponding drop-down list next to **Strain** to change the *Assignment* from “Not used” to “Replicated”.
4. Repeat the previous step for the **Batch** level and press <OK> (see Figure 26).



Level	Assignment
Strain	Replicated
Batch	Replicated
Profile	Defined

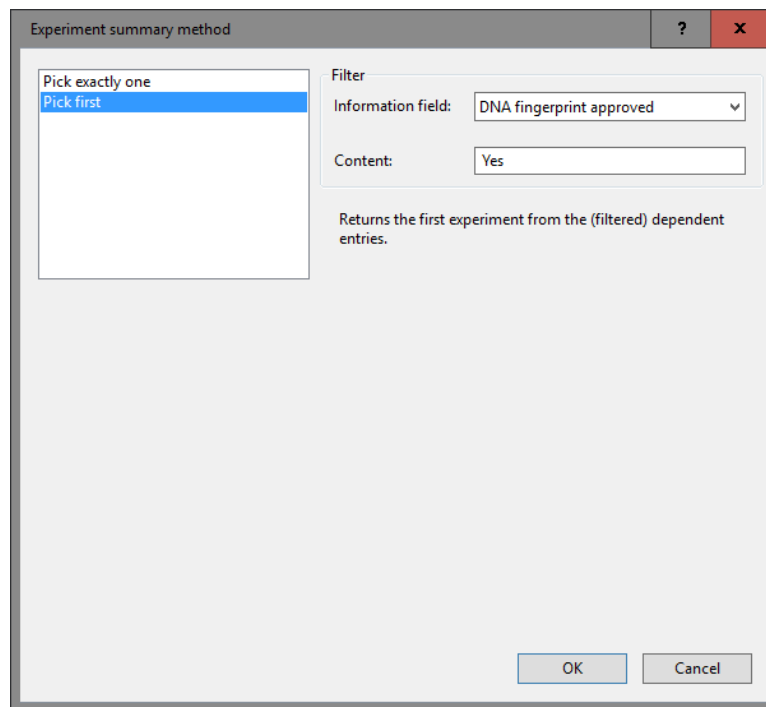
**Figure 26:** Updated level assignments for *AFLP4*.



An experiment type that was created in a database without levels or an experiment type that was created on-the-fly (e.g. during import of experiment data) will be defined at all levels. In this case, you need to check *Specified for each individual level* and manually specify at which level the experiment type should be defined and replicated.

The method used to replicate the experimental information is specified in the summary replication settings.

5. In the *Fingerprint type* window, select **Settings** > **Summary replication settings...** to open the *Experiment summary method* dialog box (see Figure 27).



**Figure 27:** Summary replication settings for AFLP4.

We will specify following filter: if the field **DNA fingerprint approved** contains the text “Yes”, this means that a curator has checked the profile and the profile can be considered for replication to the parent levels.

With the option **Pick exactly one**, no experiment will be created at the parent level(s) if there is more than one fingerprint approved. With the option **Pick first** the first encountered pattern will be replicated.

6. Select **Pick first**, pick **DNA fingerprint approved** from the drop-down list as **Information field**, enter “Yes” as **Content** (see Figure 27) and press <OK>. Close the *Fingerprint type* window.

Since no fingerprints are yet approved (**DNA fingerprint approved** all set to “No”) no profiles are summarized in the **Batch** and **Strain** levels.

The imported profiles can be checked and compared with the original DNA fingerprints from the strains. The original DNA fingerprints can be imported and stored in the database and flagged with a specific information field (e.g. an information field **Reference** with the states **Yes** and **No**).

In this example database, the reference profiles are not present so they cannot be included in the clustering. For completeness, the clustering steps are given below:

7. Make a selection of profiles in the **Profile** level. Press <Ctrl+A> to select all profiles at once and press **Edit** > **Create new object...** (🟢) in the *Comparisons* panel to create a comparison.
8. Click on the 📁 next to the experiment name **AFLP4** in the *Experiments* panel to display the **AFLP4** patterns in the *Experiment data* panel.

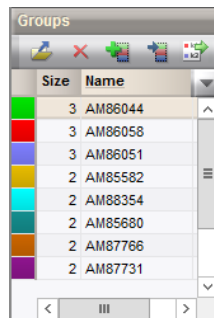
Comparison groups can be defined from clusters, from database fields, or just from any selection you want. Here we will let BioNumerics create groups based on the **Strain number**.

9. In the *Comparison* window, right-click on the field name **Strain number** in the *Information fields* panel, and select **Create groups from database field**.

10. Keep the first option selected, specify a **Maximum count** of "8" since only 8 strains have replicates in this comparison and confirm.

A message will appear listing the number of groups found in the selected field and the number of groups created based on the defined settings.

The groups are listed in the *Groups* panel (see Figure 28). The group color is displayed next to each entry in the *Information fields* panel.



**Figure 28:** Comparison groups.

11. Make sure **AFLP4** is selected in the *Experiments* panel and select **Clustering** > **Calculate** > **Cluster analysis (similarity matrix)**...
12. Select **Pearson correlation** from the list.
13. Enter an **Optimization** of 0.1%, and leave all the other settings at their defaults.

The **Optimization** setting limits the amount of movement for each fingerprint as a whole.

14. Press <Next>.
15. Select **UPGMA** and press <Finish> to start the cluster analysis.

When finished, the dendrogram and the similarity matrix are displayed in their corresponding panels. The cluster analysis is listed in the *Analyses* panel of the *Comparison* window.

If the reference profiles were present for each strain in the *Comparison* window, one could very easily see which profiles have a perfect 100% match with their reference. For these accepted profiles the state of the information field **DNA fingerprint approved** can be changed from "No" to "Yes":

16. Select all profiles that have a 100% match with their reference profile.
17. Close the *Comparison* window and make sure the *Database entries* panel is the active panel in the *Main* window. Select **Edit** > **Information fields** > **Edit field in selection...** (**Ctrl+M**), select **DNA fingerprint approved** as field, and set the new field content to **Yes** (see Figure 29). Press <Yes> twice to confirm the action.

The field content is updated (see Figure 30) and the accepted profiles are replicated to the parent levels.

If you click on the **Batch** or **Strain** level in the *Database design* panel the replicated profiles are indicated with a purple dot in the *Experiment presence* panel indication their replication status (see Figure 31).



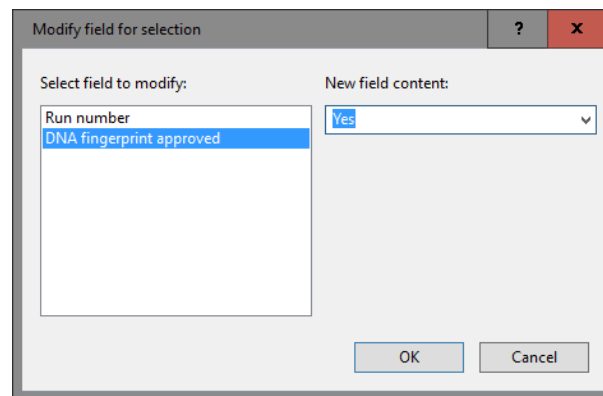


Figure 29: Modify field for selection.

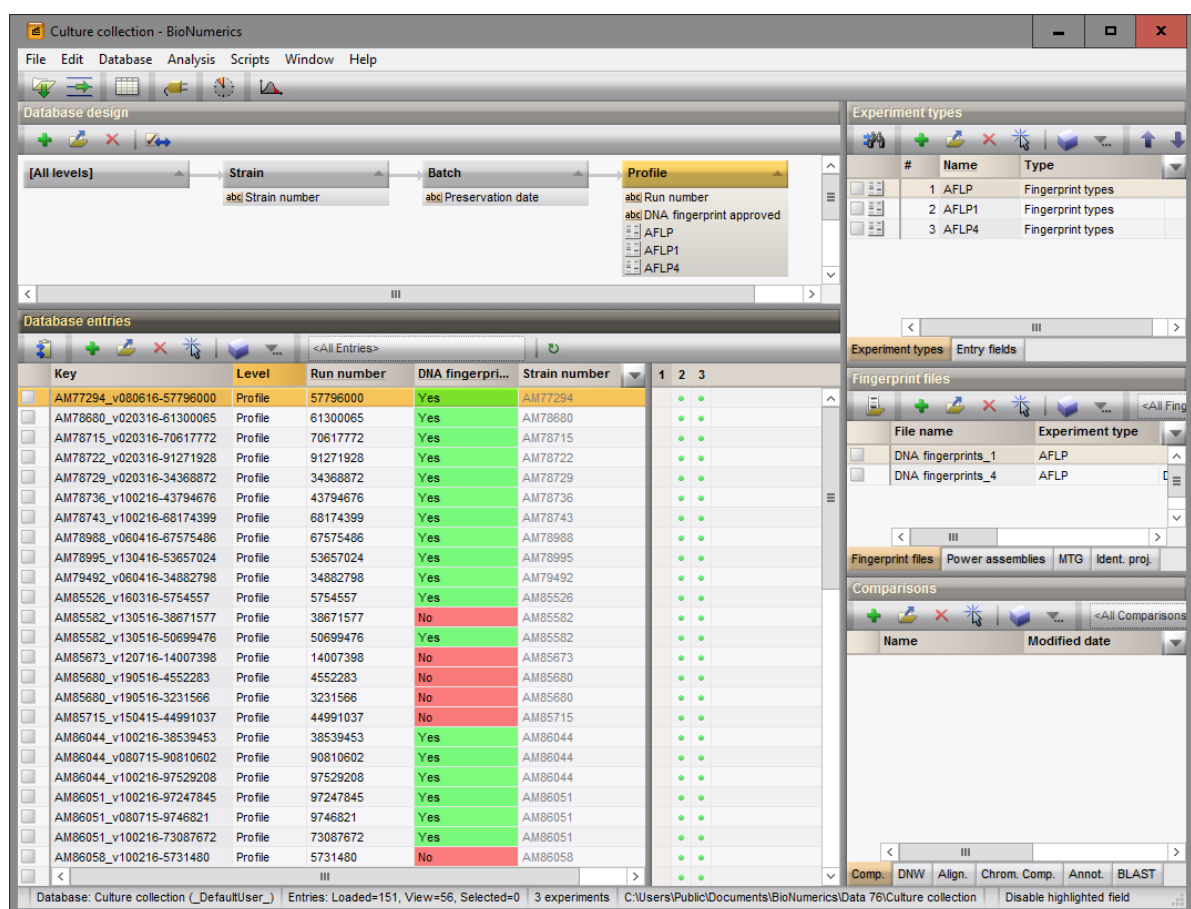
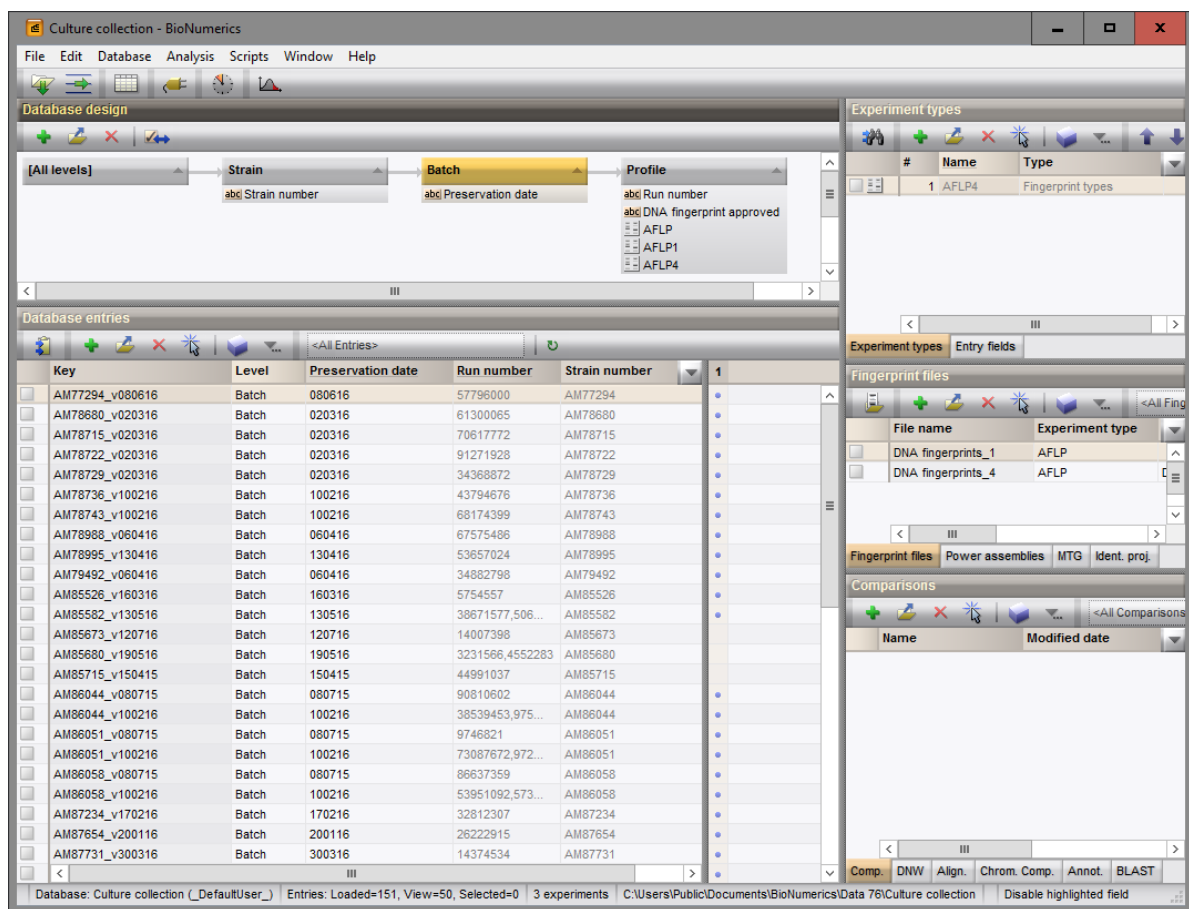


Figure 30: Modified fields.



**Figure 31:** Replicated data displayed in parent levels.