



Manual of SonoChiro® 3.0



I) Introduction

I.1) Purpose and framework for the software

SonoChiro® is a software analysing automatically ultrasound recordings of bats, be it in time expansion or in real time. This software provides a valuable help for all users of bat detectors, in particular in case of unattended recorders accumulating large amounts of data. Its diverse functions make it useful in many different contexts of analysis: inventorying species at a site, counting bat passes, quantifying hunting activity (feeding buzzes), highlighting social activity, etc.

SonoChiro® cannot completely substitute for a manual identification since a zero error rate is unattainable in the current state of knowledge and technological advances. However, SonoChiro® has been designed for maximum ease of the treatment of its own mistakes, especially through a set of relevant confidence indices. Thus, the **time saved** through the use of SonoChiro® is considerable. This varies depending on many factors (objectives, recording quality, etc.) but it is **generally greater than 90%**, it even exceeds 99% in many cases.

I.2) Principle of operation

SonoChiro® process recordings in two phases: **detection and classification**.

The **detection** process consists in localizing then characterizing a maximum number of signals potentially emitted by bats. SonoChiro® has indeed been designed to ensure a maximum sensitivity in bat calls detection, in order to detect even the most discrete species, even in case of weak signals and/or poor quality recordings. This approach result in large numbers of parasites being, in this preliminary phase, considered as potential bat calls, but these are easily discarded during the next phase (see also par IV, sensitivity settings).

The **classification** process is backed up by the characterization of previously detected signals. This classification operates on each file on which the software has detected potential bat calls. SonoChiro® determines first if the file contains calls from one or two species of bats. In the first case, the classification operates on all the bat calls detected in the file, considered forming a single “bat pass”. In the second case, the classification operates separately on the two subsets of bat calls, identified as being part of two different “bat passes”. At the end of this phase, each bat pass benefit from a 4-level identification:

- (1) An identification at species level, accompanied by a confidence index going from 0 to 10.
- (2) An identification at a species group level, thus less accurate but more reliable, also accompanied by a confidence index going from 0 to 10.
- (3) An index of feeding buzz presence (lbuz) highlighting a prey catch, thus a hunting behaviour, also from 0 to 10.
- (4) An index of social calls presence (lcs) highlighting the proximity to a roost for numerous species, also from 0 to 10.

Associating a **confidence index** to each level of identification is an **essential supplement** to the identification itself. SonoChiro® has indeed been designed in such a way that each confidence index closely reflect error risk in the identification. Thus, the user can identify for each analysis, a threshold in the confidence index below which identifications are false or doubtful. He/she can then mass process these “errors” for maximum time saving.

Finally, some complementary quantitative information is added for each bat pass: number of calls, median dominant frequency, median interval and signal quality (cf. V).

In development: future updates will allow SonoChiro® to detect more than 2 species at one time, in case of multi-species and intense activity.

I.3) Geographical and taxonomic coverage

SonoChiro® currently covers **31 of the 39 European species** (cf. list below). The learning process of the software has been performed on several millions of calls, recorded all over Europe, from Lithuania to Spain and from Serbia to Ireland, with a minimum of 1000 calls for each considered species.

Code	Scientific name	English name
Barbar	<i>Barbastella barbastellus</i>	Barbastelle
Eptnil	<i>Eptesicus nilssonii</i>	Northern Bat
Eptser	<i>Eptesicus serotinus</i>	Serotine
Hypsav	<i>Hypsugo savii</i>	Savi's Pipistrelle
Minsch	<i>Miniopterus schreibersii</i>	Bent-wing Bat
Myoalc	<i>Myotis alcathoe</i>	Alcathoe Bat
Myobec	<i>Myotis bechsteinii</i>	Bechstein's Bat
Myobly	<i>Myotis blythii</i>	Lesser Mouse-eared Bat
Myobra	<i>Myotis brandtii</i>	Brandt's Bat
Myocap	<i>Myotis capaccinii</i>	Long-fingered Bat
Myodas	<i>Myotis dasycneme</i>	Pond Bat
Myodau	<i>Myotis daubentonii</i>	Daubenton's Bat
Myoema	<i>Myotis emarginatus</i>	Geoffroy's Bat
Myomyo	<i>Myotis myotis</i>	Greater Mouse-eared Bat
Myomys	<i>Myotis mystacinus</i>	Whiskered Bat
Myonat	<i>Myotis nattereri 'sensu stricto'</i>	« Northern » Natterer's Bat
MyospA	<i>Myotis cf. nattereri sp. A</i>	« Southern » Natterer's Bat
Nyclas	<i>Nyctalus lasiopterus</i>	Greater Noctule
Nyclei	<i>Nyctalus leisleri</i>	Lesser Noctule
Nycnoc	<i>Nyctalus noctula</i>	Common Noctule
Pipkuh	<i>Pipistrellus kuhlii</i>	Kuhl's Pipistrelle
Pipnat	<i>Pipistrellus nathusii</i>	Nathusius' Pipistrelle
PippiM	<i>Pipistrellus pipistrellus</i>	Common Pipistrelle 'Mediterranean type'
PippiT	<i>Pipistrellus pipistrellus</i>	Common Pipistrelle 'Temperate type'
Pippyg	<i>Pipistrellus pygmaeus</i>	Soprano Pipistrelle
Pleaur	<i>Plecotus auritus</i>	Common Long-eared Bat
Pleaus	<i>Plecotus austriacus</i>	Grey Long-eared Bat
Plemac	<i>Plecotus macrobullaris</i>	Alpine Long-eared Bat
Rhieur	<i>Rhinolophus euryale</i>	Mediterranean Horseshoe Bat
Rhifer	<i>Rhinolophus ferrumequinum</i>	Greater Horseshoe Bat
Rhihip	<i>Rhinolophus hipposideros</i>	Lesser Horseshoe Bat
Tadten	<i>Tadarida teniotis</i>	European Free-tailed Bat
Vesmur	<i>Vespertilio murinus</i>	Parti-coloured Bat

List of species covered by SonoChiro®. Details: species code used by the software and corresponding scientific names and English names.

You'll notice that the list contain 33 entities for 31 species. Two taxa, each usually considered as a single species, has indeed been splitted in two entities, on the basis of recent publications for Natterer's Bat (Puechmaille et al. 2011 ; Salcini et al. 2011) and on the basis of noticeable differences in calls for the Common Pipistrelle, between individuals from the Mediterranean Basin and those from temperate regions.

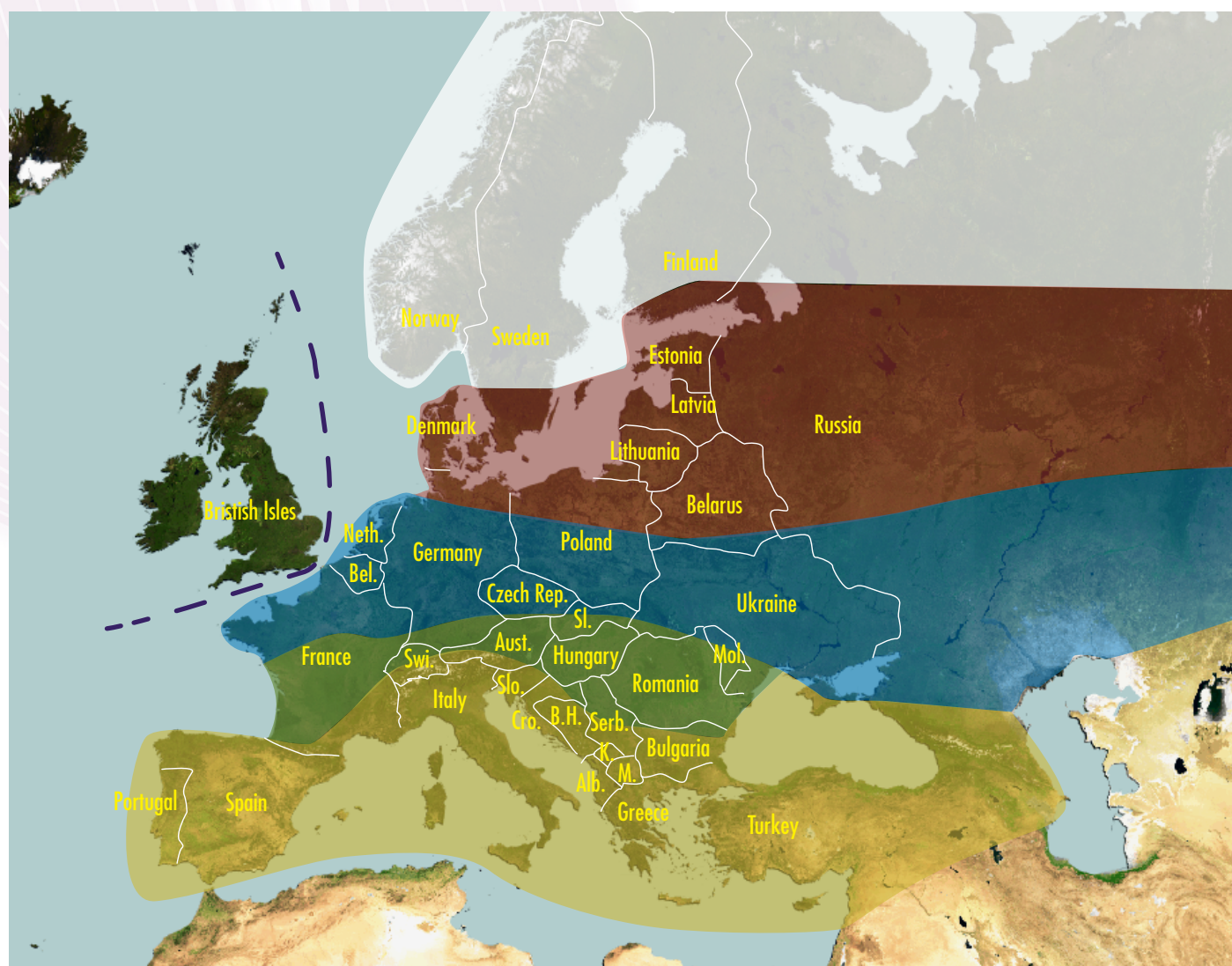
In addition, the temporary absence of eight of the European species will cause little harm to SonoChiro® users wherever the localization of their recordings. For seven of these eight species, no reliable criteria regarding their calls has indeed been described because they emit almost identical calls from commoner species which are covered by SonoChiro®. Hence, if these species are recorded by a user, they will be assigned to their commoner “acoustic counterpart”. There remains Blasius’ Horseshoe Bat (*Rhinolophus blasii*) whose range is restricted to southern Balkans. In the current state of SonoChiro®, this species will be most often assigned to its closest species: the Mediterranean Horseshoe Bat.

In development: Blasius’ Horseshoe Bat is expected to be incorporated into SonoChiro® in the course of 2013, as well as Isabelline Serotine, Escalera’s Bat and Felten’s Bat.

The difficulties of identification of some species (ex: *Plecotus* spp., *Myotis* spp., etc) led us to define species groups in order to offer a second level of identification, less accurate but more reliable. These groups are detailed in the table below. A workbook entitled « SpList_Geo.ods » gives the connections between species and groups which slightly vary between geographical regions. This workbook can be downloaded on SonoChiro® webpage: <http://www.leclub-biotope.com/366sonochiro-eng.html>.

Code	Définition
ENVsp	<i>Eptesicus</i> or <i>Nyctalus</i> or <i>Vespertilio</i>
MyoHF	‘High Frequency’ Myotis (<i>Myotis</i> sp. hors couple <i>blythii</i> / <i>myotis</i>)
MyoLF	‘Low Frequency’ Myotis (<i>Myotis blythii</i> / <i>myotis</i>)
Myosp	<i>Myotis</i> sp. – all species
NlaTt	Greater Noctule or Free-tailed Bat (<i>Nyctalus lasiopterus</i> / <i>Tadarida teniotis</i>)
Pip35	Pipistrelle of the group ‘Kuhl/Nathusius/Savi’ (<i>Pipistrellus kuhlii</i> / <i>nathusii</i> + <i>Hypsugo savii</i>)
Pip50	Pipistrelle of the group Common/Soprano (<i>Pipistrellus pipistrellus</i> / <i>pygmaeus</i>)
PipMi	Pipistrelle or Bent-wing Bat (<i>Pipistrellus pipistrellus</i> / <i>pygmaeus</i> + <i>Miniopterus schreibersii</i>)
Plesp	Long-eared Bat (<i>Plecotus</i> sp.)
RhiHF	‘High Frequency’ Horseshoe Bat (<i>Rhinolophus euryale</i> / <i>hipposideros</i>)
Rhisp	Horseshoe Bat (<i>Rhinolophus</i> sp.) – all species

To maximise SonoChiro® efficiency in function of recordings location, **six geographical regions** has been designed on biogeographical criteria. These regions allow narrowing the identification to only species which are potentially present where the recordings were performed. Hence, the confidence in the identification is maximised.



- Northern Boreal
- Southern Boreal
- Northern Temperate
- Southern Temperate
- Mediterranean
- British Isles

II) Requirements

1) Configuration

Windows XP/Vista/7/8 32/64 bits + 2 Go RAM + DualCore compatible x86 1 GHz Processor

2) Audio files

The use of SonoChiro® needs acoustic recordings in WAVE mono format and whose duration are inferior to 20 seconds (200 seconds in 10x expanded time). However, the analysis of stereo and/or longer files is easy thanks to freewares allowing the splitting of shorter and/or mono files. Examples of these freewares are Kaleidoscope (Wildlife Acoustics) and Wavosaur. The optimal duration of files to be processed by SonoChiro® is 5 seconds. This duration corresponds to an average bat pass, it is hence commonly used to quantify bats activity (cf. Barataud 2012).

Particular case : in SM2BAT recordings, we recommend to use the filter associated to their microphone « SMX-US » during the extraction of WAVE files from WAC files. This frequency filter maximises performance of SonoChiro® on such recordings.

3) Recommended complementary softwares

The use of SonoChiro is most effective when accompanied with the use of a spreadsheet software (Excel or Calc) and the use of a sonogram display software (cf. VI for more details).

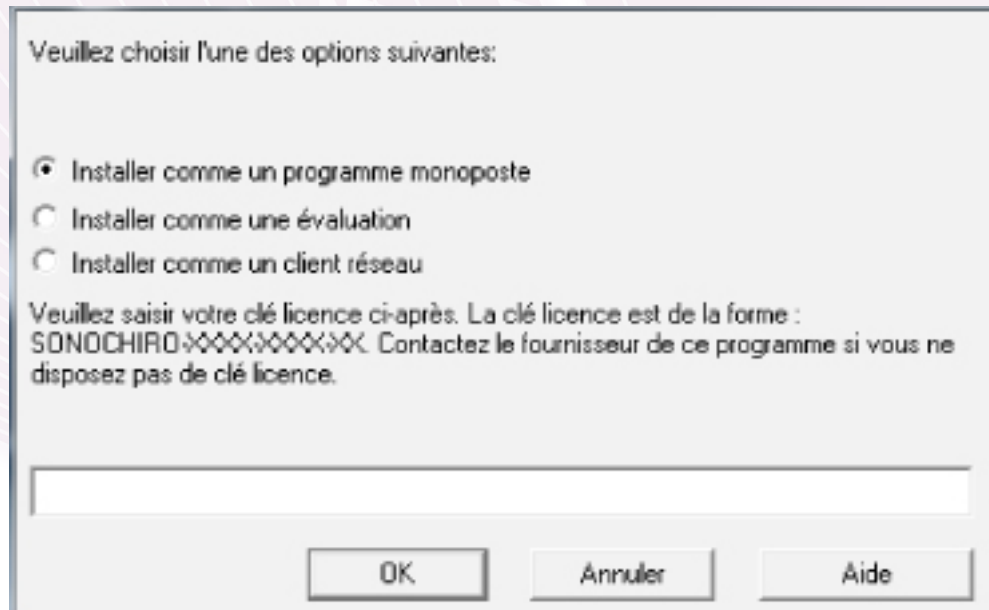
III) Installing and launching SonoChiro®

1) Installation

- Run « SonoChiro®_setup.exe »
- Follow installation instructions
- Run SonoChiro® from your desktop or your program list

2) Registration (Beware, an internet connexion is necessary to fulfil this step)

- Choose the first option « Installer comme un programme monoposte »



- Copy below your Licence Key that you received soon after your subscription, and press OK
- Type your contact information in the next window, and press OK
- Registration will be checked for an instant and SonoChiro® will be launched

3) Classifiers

SonoChiro® cannot run without classifiers. It will then be needed to download at least one of the six classifiers available on our web page (<http://www.leclub-biotope.com/366sonochoiro-eng.html>) according to where are located your recordings (cf. I.3). The downloaded classifiers must then be extracted towards the “Classifiers” directory of where SonoChiro® is installed (ex: « C:/Program Files/SonoChiro®/Classifiers/M » for the Mediterranean classifier). If no classifier are present in this directory, a warning message will appear as soon as SonoChiro® is run.

Beware: The downloaded directories must not be renamed, as well as their content!

IV) Interface

The interface has been designed in such a way as to be the most easy to use. Hence, Only 8 parameters must be set:

(1) WAV directory: the user has to choose the directory containing the audio files to be analysed.

(2) Output: l'utilisateur crée le fichier de sortie qui contiendra les identifications automatiques et informations complémentaires.

(3) Type of detector: the user sets if these recordings are from Wildlife Acoustics detectors or not. This allows SonoChiro to add time, date and place data in the output. Collecting time and date data also from other types of detectors such as D500 (Pettersson) is expected in 2013.

(4) Region: the user sets the geographical region where the recordings were made, thus the list of potential species considered by SonoChiro®.

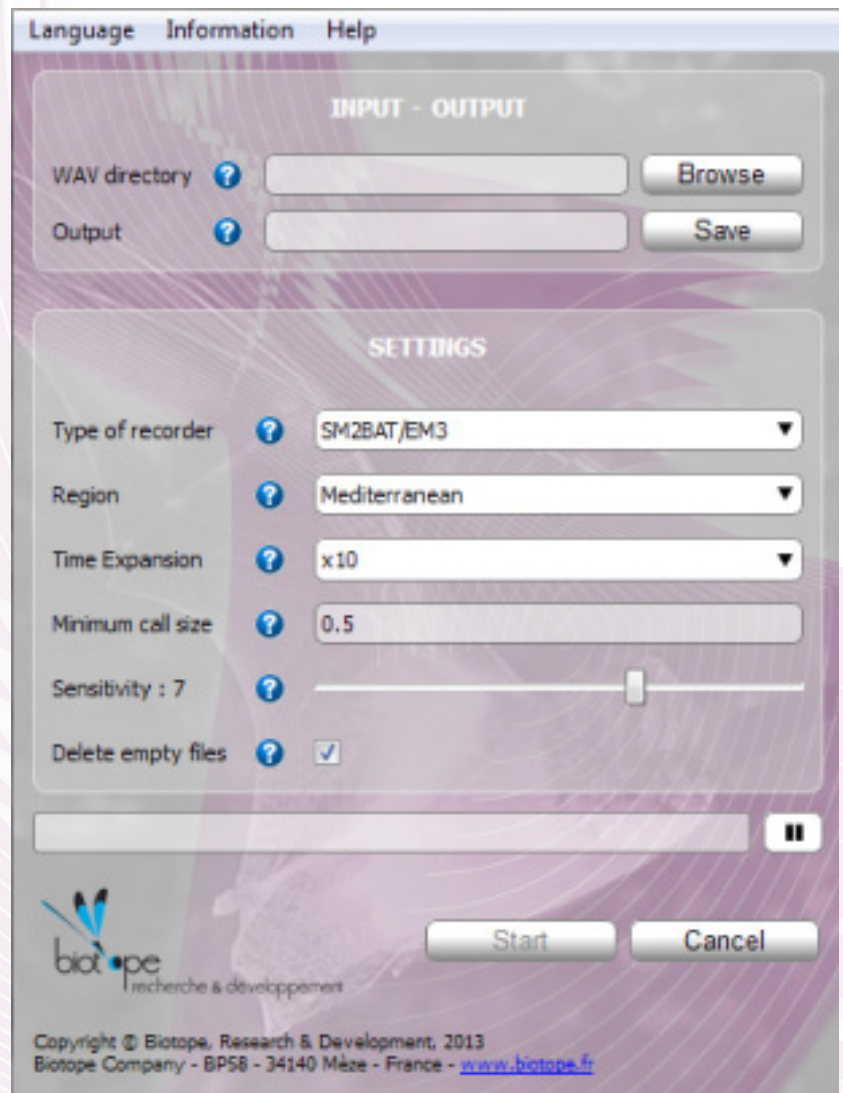
(5) Time Expansion: the user sets if the files are in real time (x1) or time expanded (x10).

(6) Minimum call duration: the user sets if he/she wants to filter the shortest calls. By default, SonoChiro® looks for every calls of more than 0.5 ms, thus every single calls emitted by bats. However, if the user is looking for specific taxa or type of calls, he/she can increase this value in order to reduce the output, thus his/her time of analysis.

(7) Sensitivity: this setting is meant to adapt to users purpose. To guide the user, we cite two extreme examples: looking for even extremely weak and altered signals (sensitivity 10) and filtering to the maximum bad quality sequences (sensitivity 1). The sensitivity is set to 7 by default, this constitute a good compromise (cf. VI for more details).

(8) Delete empty files: the user set if he/she wants to suppress automatically files on which SonoChiro® did not detect any bat calls, in order to save hard disk space.

NB: each session of SonoChiro® uses only one core of your processor. It might be advantageous to run simultaneously several sessions of SonoChiro® to reduce the machine time of the analysis.



V) Output table and its interpretation

SonoChiro® presents the results of its analysis in the form of a table of the CSV format. Every line of this table correspond to a bat pass on which these fields are filled:

- (1) **File:** the name of the file containing the bat pass
- (2) **Contact:** specify if it is the main bat pass of the file (« Main ») or if it is a bat pass in the background of the main one ("Secondary").
- (3) **Id:** Temporary identification of SonoChiro®. According to confidence indices, Id is set to the species level (if ISp > 5) or the group level (if IGp > 5) or to "Chirosp" instead. This field is meant to be edited by the user according to what has been observed on the samples that were checked (cf. VI for more details).
- (4) **Group:** the identification at the group level
- (5) **IGp:** the confidence index associated to the group identified. Vary from 0 to 10.
- (6) **Species:** the identification at species level
- (7) **ISp :** the confidence index associated to the species identified. Vary from 0 to 10.
- (8) **NbCalls:** the number of calls on which the identification has been made.
- (9) **MedFreq:** the dominant frequency, more precisely the median among calls of the peak energy frequency.
- (10) **MedInt:** the median interval between calls giving an indication of the rhythm. If the measured rhythm is found to be unreliable because of the presence of several individuals or because of numerous echoes, this parameter takes a null value.
- (11) **IQual:** an index of the bat pass signals quality that could impact both SonoChiro® performance and the user's ability to analyse the bat pass. Vary from 0 to 10.
- (12) **Isc:** an index highlighting the presence of social calls. Vary from 0 to 10.
- (13) **Ibuz:** an index highlighting the presence of feeding buzzes. Vary from 0 to 10.

Note : in the "Group" or "Species" fields, the value "parasi" can appear. This indicates that the file probably contains only parasites but that there is a significant chance that bat calls are present.

In the case of data about time, date and place are available (currently only for SM2BAT and EM3 from Wildlife Acoustics), these fields are added in between « ISp » and « NbCalls »:

- (1) Year: in the form YYYY
- (2) Month: numerical
- (3) Day: numerical
- (4) Hour: numerical
- (5) Minute: numerical
- (6) Date: in the form DD/MM/YYYY
- (7) Time: in the form HH:MM
- (8) Night_Date: the date of the beginning of the night. It allows separating nights from each other (useful for overview tables). In the form DD/MM/YYYY.
- (9) Place: return the beginning of the file name, thus the name of the sampled site if detectors were programmed in this way. This also can be done *a posteriori* by a renaming freeware like LupasRename

Overview output tables will be added in next updates of SonoChiro®

VI) Advices and tips

VI.1) Good quality recordings: time saved later!

The environment of the recording microphone and of the recorded bat alters the transmission of the signal, reducing the ability of SonoChiro® to analyse all the information contained. To simplify, SonoChiro®'s worst enemies are (1) echoes and (2) parasites. The user has thus every interest in preventing these problems to occur as soon as the recordings are being set. We cite here a few rules to follow in order to **maximise the quality of your recordings** (non-exhaustive list):

- (1) Put the microphone at least 1 meter from ground if possible, if not the higher as possible.
- (2) Separate the microphone from the recorder box through a cable.
- (3) Do not put the microphone deep in the vegetation. If it is attached to it, it should be positioned the most "at the end of branches".
- (4) Direct the microphone over the horizontal and towards a space as open as possible, especially if the microphone is deemed directional.
- (5) More generally, maximise the chance that the space between the recorded bat and the microphone is clear of elements producing echoes.

VI.2) Later: tackling the quantity of generated data

Many of you experience (or are going to) the « overwhelming data syndrom », a consequence of the impressive multiplication of the recording durations allowed by the arrival of unattended recorders. This literally overwhelms the bat experts under **the quantity of data to analyse**, keeping them behind their computer and frustrating them to not be able to well exploit this wealth of data. SonoChiro® has been developed as to avoid these annoyances but to make optimum use of it requires a minimum of practice.

This part of the manual will give you several **advices and warnings** in order to hoist you into the saddle as quickly as possible. A few situations are given as examples to guide you. After several tests, you will know how to adapt your use of SonoChiro® to your own specific needs.

As a reminder, SonoChiro® is better used in parallel with:

- A **spreadsheet software** like Calc or Excel in order to view the output tables and, above all, to be able to filter and to sort the data according to the identification but also according to confidence indices and additional parameters.
- An **acoustic software** which allows viewing **sonograms** of your recordings files. Among the free-ware offering this function, there is Syrinx (John Burt, <http://www.syrinxpc.com/>) which is Windows based. This freeware offer interesting functions for rapid validation of the data, we therefore propose a specific tutorial on our web page (<http://www.leclub-biotope.com/366sono-chiro-eng.html>). Another example: Audacity which works also on Linux and MacOS.

The advices given in this part follow a chronological order divided in three phases:

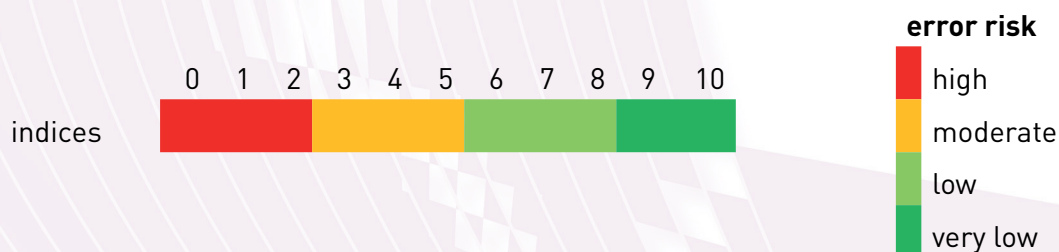
- (1) **Take a look at the data:** what information can you immediately extract from the data produced by SonoChiro®?
- (2) **Validate the data:** what is the protocol to gain a maximum amount of time while making the fewest mistakes as possible?
- (3) **Analyse the data:** a few examples of overview tables of your validated data

1st step : take a look at the data

Spreadsheet softwares have several tools available for users that facilitate the reading of SonoChiro® outputs:

- (1) **Freezing/Fixing:** by designating the 2nd cell of the 8th column, this tool allows freezing both titles and 7 first columns containing the most essential information. Hence, these elements remain permanently visible while the user scrolls on the whole table.
- (2) **Filtering:** This tool allows displaying only a part of the data according to the values of any field. For example, this allows displaying the data of only one sample point or only one date or only one species or the identification with a certain amount of confidence, etc. This tool is precious in the data validation phase (cf. following part)
- (3) **Sorting:** this tool allows organizing the display of data in the order desired. This can be used in the same way as the Filtering. However, it turns out to be less convenient. That is why, we advise in most cases to keep the chronological order because it allows viewing simultaneously bat passes which are temporally linked (a same individual producing several successive bat passes for example). Data selection is better done through the Filtering.
- (4) **Conditional formatting:** This tool allows traducing numerical values of confidence indices in a colour scale (from red to green for example) and thus facilitating their reading. One can also use this tool to view the information of a column in another in order to view more information on the screen. For example, it is possible to view the presence of feeding buzzes or social calls in the first columns to avoid consulting each time the Ibuz and Ics and the right end of the table. In practice, one only has to select a column, the "File" one for example, and to apply a conditional formatting of this kind: « =W2>4 » associated with green color. The "File" column will then display green cells if Ibuz is over 4.

This then tempts the user to detail directly the output table. It will then be **necessary to cross-check the identification** (at species or group level depending on purpose) **with its associated confidence index**. Confidence indices can take 11 different values from 0 to 10 in order to give maximum information to the user during the validation phase (see below). However, it's possible to apply the following interpretation grid in order to gain an idea of the reliability of SonoChiro®'s identifications.



Despite this, it can be **difficult to directly interpret the table due to its size**: 13 columns minimum and often thousands of lines if recordings have lasted at least a whole night.

Hence, to get a first insight of your data, it is more efficient to produce a **contingency table** (sometimes called **pivot table**) of the output rather than reading random samples of an enormous table. This contingency table will be defined to display (1) identified entities (groups or species) in lines, (2) corresponding confidence index in columns and (3) the number of bat passes in value. Here is one example:

Species	0	1	2	3	4	5	6	7	8	9	10
Barbar	2	1	1	3	4	3	2	1	3		
Eptser						1					
Hypsav	4	2		1	4	3	10	13	17	26	22
Minsch	1			1	3	2	5	7	3		
Myobly	4	2	4	2	1	1					
Myocap		4	1								
Myodas	1										
Myodau	5	8	8	5			1				
Myoema		1									
Myomyo				1		1					
Nyclei	1	1		1		1					
Pipkuh	5	2	4	6	11	30	24	11			
Pipnat	2	1	4	5	6	12	6	12	3		
Pippip	10	8	11	25	36	49	70	81	85	85	43
Pippyg	2	1			3	1	1		1	1	
Pleaur	2										
Pleaus	6	1	1	1		1					
Plemac	6	2	1	1	1	1			1		
Rhifer											1
Rhihip	2	1	1	1							
Tadten		1				1					

Example: contingency table based on a SonoChiro® process of a whole night recording at a forest pool (Ardèche, France)

Cross-checking the interpretation grid with this contingency table, one can quickly summarize the probability of presence of each species:

- **Almost certain** for Common and Savi's Pipistrelle which both scored high confidence indices on a large number of bat passes
- **Very probable** for Soprano Pipistrelle and Greater Horseshoe Bat, each getting one bat pass with very strong confidence
- **Probable** for Barbastelle, Bent-wing Bat, Daubenton's Bat, Alpine Long-eared Bat, Kuhl's and Nathusius' Pipistrelle
- **Possible** for other species

Numbers of bat passes also allow getting an idea of activity levels. But to go even further, it is necessary to proceed to the second step: data validation.



2nd step: validating the output

This step requires that **a sample of the recordings would be manually checked** by “expert judgement”. Thus, in addition to the spreadsheet software, it requires examining recordings through at least sonogram visualization, a function performed by two freewares we previously cited (Syrinx and Audacity). Moving from the table to the sonograms can be instantly done by (1) copying the wished “File” cell (Ctrl+C) then (2) pasting it (Ctrl+V) in the “Open” menu of the audio software.

Particular case: in Syrinx, it is preferable to use Ctrl+L shortcut rather than the “Open” menu. This allows opening files in place of the previous one, conserving viewing settings, particularly the link between large and zoom windows (cf. specific tutorial downloadable on our web page).

After this “warm up”, the user needs to know how to go about the validation, in other terms:

► How to choose the files to be manually checked?

This choice depends on the user’s purpose and his/her requirement in terms of exhaustivity and accuracy. Hence, there is no recipe which can fit every situation. We give below two examples of common and contrasting situations for you to get an idea of your possibilities.

Cas 1 : You intend to inventory the list of species present on a site

For this purpose, simply check **one single bat pass per species** identified by SonoChiro®: the one which got the highest confidence index and which consequently got the highest probability to belong to the species. Either the identification of **SonoChiro® is right, the species is thus really present, or SonoChiro® is wrong, the species can then be considered as missing.**

For the sake of prudence and completeness, you can check up to three more bat passes among the highest confident ones, but it is useless to go any further because **it is extremely rare that a species is present without its highest confident identifications being right.**

On the event of a tie on the confidence indices, you can add a second criterion by selecting the file with **the highest quality index (IQual) and/or the largest number of calls (NbCalls)**. This can be particularly useful for *Myotis* species whose confidence indices are generally low and manual identification is difficult.

This method allows checking generally **only 10 to 25 files for 100 to 8000 recorded ones in the case of a whole night** (this ratio would be better or lower according to recording duration). If you do not bother to identify some difficult species groups like *Myotis spp.*, the number of files to be checked is even noticeably lower.

Case n°2 (ambitious): You intend to quantify the activity of each species

If you wish to quantify the activity of a species, it becomes necessary to check additional files because the highest confidence index can't be considered representative for the other ones and, if it's valid, giving a guarantee that all files allocated to the species are valid. But be careful, this doesn't mean to check every single bat passes (generally useless) but to estimate the number of bat passes corresponding to each species. In most cases, a given level of imprecision ($\pm 20\%$ for ex.) in this estimate is entirely tolerable since the measured value of activities vary over several orders of magnitude between sites and between species

Below is exposed a protocol under the form of a dichotomous key which allows setting a minimal sample of file to be checked while being representative of the whole output:

As in the first case, it begins with checking the bat pass with the highest confidence index for a species.

A) Identification is right

- AA) A majority of the other bat passes have similar values of confidence index
 - AAA) the species is not rare = **you can validate all the bat passes of the species**
 - AAB) the species is possibly rare = you check at least 3 more bat passes in order not to overestimate the activity of the species
 - AABA) there is no error = **you can validate all the bat passes of the species**
 - AABB) errors are found = **you check at least a dozen of bat passes to estimate activity accurately**
- AB) A majority of the other bat passes of the species have much lower confidence indices than the highest = you check at least two other bat passes among the low confidence indices
 - ABA) there is no error = **you can validate all the bat passes of the species**
 - ABB) errors are found = you check at least 3 other bat passes to define to which level of confidence index, errors correspond = **you can validate all the bat passes which are over this confidence level** and pass to B for others

B) The identification is wrong: you check at least three other bat passes

- BA) The error is systematically the same (a specific species or parasites) = **you correct all the bat passes concerned to the species manually identified**
- BB) the bat passes checked did not all correspond to the same species = **you check at least 6 other bat passes in order to estimate the proportion of each species**

Validating or correcting can be easily mass processed on your table thanks to “**Id**” field. This column has indeed a vocation to be edited in such as to constitute the final identification at the end of this step. On the opposite, it is advised not to edit the column “Group” and “Species” to keep track of the identification of SonoChiro®. **In practice**, you’ll need to a “Filter” on your spreadsheet in order to isolate bat passes belonging to one or another species or groups, according to selected criterion (Group/Species/Index). You then type the manual identification in the first cell of “Id”, copy it (Ctrl+C), select all other cell downwards (Ctrl+Shift+↓) and paste (Ctrl+V).

Comment: this protocol intend to be a guide in the intial steps taken by the user. The experience subsequently accumulated will allow the user to progressively deviate from it and/or to ameliorate it, according to analyses purposes. The consideration of additionnal parameters like the number of calls, the rhythm, the frequencies or the behaviour (feeding buzz / social calls) could in some case improve the management of errors.

This protocol can be used instead species groups in order to simplify this validation step. In all cases, it is advised to first filter groups before species, because some errors can be similar across a species group, thus cane be treated more rapidly in this way.

► You are still overloaded with validation time: some additional solutions

Reducing even further the time of validation is possible at the cost of eliminating **the files from which the error risk is the highest**. SonoChiro® is indeed set by default to be very sensitive and detect as many bat passes as possible, even the weakest and shortest ones (even 1 single call) in poor recording conditions. This setting allows an optimal efficiency in detection, particularly useful for discrete species which benefit from easy manual identification, even in poor conditions (ex: horse-shoe bats, Barbastelle...). However, it is reasonable to waive these sensitive settings if you want to gain more time by save yourself a large part of the error management. For this, SonoChiro®’s users have access to four tools:

- (1) **The Sensitivity setting** chosen before running SonoChiro®. Lowering this setting can drastically reduce the error rate in case of heaviliy parasitized recordings (ex: bush-crickets). Be careful, dropping sensitivity below 3 can eliminate a large part of the bat passes, particularly when a lot of bats are detected far from the detector (ex: high-flying bats recorded from the ground).
- (2) Increasing the **minimum duration of calls**. Be careful, this could rapidly eliminate species which make very short calls when they are hunting, *Plecotus* and *Myotis* particularly. This setting is thus not advised if these species are sought after.
- (3) Filtering a posteriori bat passes containg only a few calls (**NbcCalls > 2**), hence, making their identification much less reliable. Be careful, filtering bat passes over 2 calls would sometimes eliminate species calling with very slow rythm (ex: Greater Noctule or Free-tailed Bat).
- (4) Filtering a posteriori bat passes of bad quality recording (**lqual > 2**). Be careful, filtering on this criterion could eliminate a large part of bat passes if the environement of the microphone is much cluttered (forest understorey, tunnel, etc).

3rd step: analyse the data

Once validation is done, the potential of analysis are almost infinite and depends on the purpose of the user, even more than previous steps. It should, however, be noted that it is generally useful to begin your analysis by synthesising the data collected and validated. This can be done, as previously, by displaying a contingency/pivot table. Here are a few examples of forms:

- (1) Id in line, Place in column (makes easy comparison of sites)
- (2) Id in line, Night_Date in column (makes easily readable seasonal phenology)
- (3) Id in line, Hour in column (makes easily readable the temporal variation of activity within the night)
- (4) Id in line, Ibuz in column (highlight the hunting activity per species)
- (5) Many others...



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