

## RESEARCH ARTICLE

### Computer Assisted Coral Identification System: an electronic approach to identify common coral species of Sri Lanka.

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**Abstract:** A preliminary survey was carried out to find out the issues and constraints of the Polychotomous Coral Identification Key. Findings were used as the primary platform to provide a modified approach to the coral identification process. The conventional coral identification key is a paper-based model, where users often require the help of an identification expert to complete the identification process. Vast majority of the respondents (76.15%) suggested that the conventional coral identification key should be more user-friendly, including a modified key procedure, assistance with scientific terminology, and enhanced visual elements. To address the issues in an all-in-one approach, a computer application, Computer Assisted Coral Identification System was developed. It was designed to directly interact with the user & assist the identification process. User-friendliness of the Computer Assisted Coral Identification System was improvised by designing a powerful & attractive Graphical User Interface (GUI). This GUI was equipped with 16-bit high-color images, easy-navigational controls and attractively presented information. The Interactive Glossary combines information and pictorial support to provide descriptive information on scientific terminology. Further, the user is provided with some information on the coral genera that are identified using the Computer Assisted Coral Identification System. This package provides an efficient, understandable, convenient & secure approach to the coral identification process. Geared with these new features, the Computer Assisted Coral Identification System facilitates the identification of 123 common coral taxa of Sri Lankan waters upto their generic levels.

**Key words:** Coral identification, Polychotomous key, Computer Assisted Coral Identification System, User-Friendliness, GUI

## Introduction

Corals are a group of marine invertebrates thriving mostly in relatively shallow tropical oceans of the world (Taylor, Green et al., 1997). Being an evolutionary primitive form, the diversity exhibited by corals is paramount. The term “corals” refers to a broad group of cnidarians within which a wide range of species are sustained. Corals are classified under a Class known as Anthozoa, which includes two main Subclasses; namely, Subclass Octacorallia (Soft corals & Sea anemones) and Subclass Hexacorallia (Hard corals) (Richmond, 1997). Hard corals are the type of corals that contribute to build coral reefs. Due to their extensive morphological variation, these hard corals exhibit a great deal of enchantment in oceans.

One of the most prominent groups within the Subclass Hexacorallia is Scleractinian corals (Order Scleractinia). This order includes mainly reef building stony corals (Bakus, Wright et al., 1993). There is an array of species classified under the order Scleractinia, each possessing its own unique morphological variations. (Gleich, Maxeiner et al., 2004). Due to this high species diversity among the Scleractinian corals, it is obvious that a systemic methodology is required to identify each coral species. Most common method to identify coral species is the use of identification keys. The coral identification key works similar to the other identification keys (i.e. fish identification key), which uses the external characteristics of the coral specimen to identify it. These external characteristics can be morphological, morphometric and/or meristic features of the calcareous exoskeleton of the coral

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specimen (Veron, 2000). In a coral identification key, these features are organized into strongly linked, selectable categories known as ‘options’, using their similarities and dissimilarities. The selectable options are housed within much broadly defined ‘option sets’ (Fig. 1 A). In other terms, each option set branches into numerous sub options, eventually creating a complex, interconnected branching network where each branch corresponding to a particular identification feature (Fig. 1C).

User is allowed to observe the coral specimen and proceed along the coral identification key by selecting suitable options (from the desired option set). Ultimately, if the correct options are selected, the key guides the user to the desired coral species.

As furnished earlier, coral identification is based upon the morphological, morphometric and meristic variation of the coral exoskeleton. Complexity of such features increases with the progression of the coral identification key.

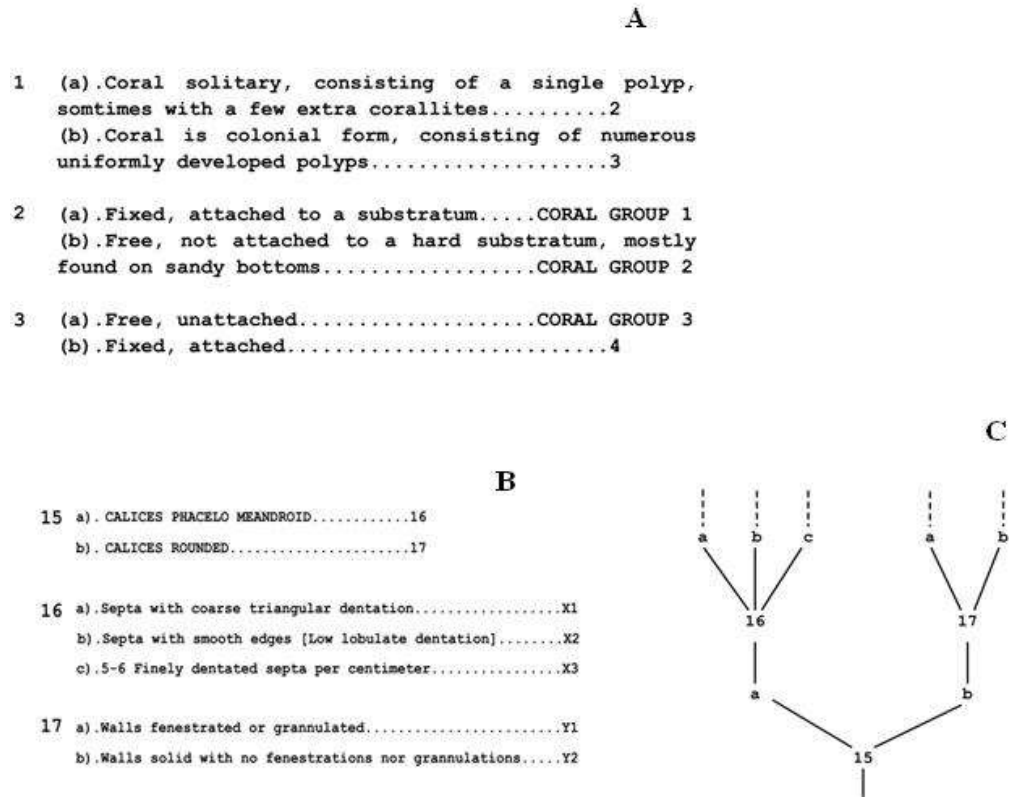


Figure 1: A. The foremost section of the polychotomous coral identification key. The numbers 1, 2, 3..etc refer to option sets. Options included under each option set are noted by letters a, b, c...Each option is linked to another option, thus forming a network. Image courtesy of Dept. of Oceanography and Marine Geology-Faculty of FMST, University of Ruhuna. B. The polychotomous nature of the coral identification key. Note that the options of the Option-set “16” forms a triplet whilst that of option-set “17” forms a couplet. Modified after the coral identification key of dept. of Oceanography and Marine Geology, Faculty of FMST, University of Ruhuna. C. A diagram showing the “flow” of a polychotomous section (shown in figure 1b) of the coral identification key.

Some of these features may include observing finer levels of skeletal variation (Veron, 1993) which requires the acquisition of a certain amount of practice and/or expertise on the subject matter. With the complex key architecture and advanced user requirements, the coral identification key can be affirmed as one of the most intricate approach of species identification.

This instinctive complexity of the coral identification keys is well understood but poorly documented. To alleviate the complexity of the coral identification process, certain measures have been undertaken by various institutions, scientists and organizations. Such approaches can be broadly categorized into two heads; the illustrative (pictorial) approach and electronic (computerized) approach. But more recently, a combination of illustrative and electronic

Due to these characteristics of the coral identification key, it is said to be a polychotomous key (Fig. 1B).

compartments is being used in assisting the coral identification process (Randler and Knape, 2007).

This study was focused on two main target areas of the conventional coral identification key. To understand the issues and constraints of it and to find out a practicable solution to overcome the above issues. User's perspective on the coral identification key was obtained by carrying out a preliminary survey, and the ideas highlighted by the respondents were used as the primary basis for working out a workable solution to the aforementioned issues.

## **Materials and Methods**

### ***Preliminary survey***

Prior to making modifications or alterations to the coral identification key, a preliminary survey was carried out to find out issues and constraints of it. This study was intended to highlight the user's perspective on the existing coral identification key. The survey was oriented on identifying issues and constraints of conventional methods of species identification (including that of corals). A sample (n) of 40 respondents (n/N = 0.5882) was randomly selected from a population consisting of Fisheries Biology students. A list of all the students following Fisheries Biology as a subject (N = 68) was obtained. Index numbers of the above students were arranged according to an ascending order. Then the sample was isolated using a random number table. Once the sample was defined, a questionnaire consisting of structured questions was distributed among the respondents. Their responses were summarized and used as the primary basis of providing a modified approach to conventional method of coral identification.

### ***Idea generation and Idea screening***

Although the basic idea of providing a modified approach to the coral identification process was instinctive, a descriptive set of opinions about 'how to modify the coral identification key' were obtained via the preliminary survey.

Ideas collected from the respondents provided the direction towards how the coral identification key could be modified. These were named as the "seven pillars of key modification" (Table 1).

Above issues were then classified under two broad categories as User-Friendliness issues and Field usage issues (Table 1). Although the scope of this study was to address the issues and constraints of the coral identification key, it was understood that both

user-friendliness issues and field usage issues could not be addressed at the same time. Therefore, Field usage issues were screened from the suggested solution.

Table 1. 'The seven pillars of key modification'. The ideas generated by the respondents subjected to the preliminary survey were used as the basis of modifying the coral identification key. 1-User Friendliness issues, 2-Field usage issues.

1	The key procedure has to be modified <sup>1</sup>
2	The key has to be equipped with more visual elements <sup>1</sup>
3	The key should provide descriptive information on scientific terminology <sup>1</sup>
4	Post identification environment must be enhanced <sup>1</sup>
5	The key should provide an attractive working environment <sup>1</sup>
6	The key should be able to be used in the field <sup>2</sup>
7	The key should encourage the user during the identification process <sup>1</sup>

### ***Suggested models***

In case of addressing the user-friendliness issues of the conventional coral identification system, two main approaches could be worked out. One of such included building up of a pictorial model, which would have been a paper-based identification key with more pictures and descriptions. The other suggested solution was to build up a computational model which uses visual and knowledge enhancements. These two contending models were subjected to a suitability study and the best model was selected to address the user-friendliness issues of the conventional coral identification process. A brief comparison of the two contending models is given in table 2.

### ***The Computer Assisted Coral Identification System***

The heart of the idea that the computational model was designed was to create a Graphical User Interface (GUI). The designing process of the Computer Assisted Coral Identification System involved several steps, i.e. designing the main user interface, designing multi-level loading windows (Key process design), designing of species fact sheets and glossary elements, establishing connections and links, establishing security/privacy and the generation of the final output.

### Designing the Main User Interface

The main user interface is the compartment where the user interacts with the coral identification key.

Since it generates the initial expression on the user,

Table 2. Comparative details of the two contending suggested solutions for coral identification. Note that the numbers 1, 2 and 3 refer to High, Medium and Low level of reliance respectively.

Suggested Model Degree of Reliance	Pictorial Model			Computational Model		
	1	2	3	1	2	3
<b>Feature</b>						
User-Friendly key process			+	+		
Use of Visual Elements		+		+		
Scientific Descriptions	+			+		
Attractive Working Environment		+		+		
User Encouragement		+		+		
Post-Identification Enhancement	+			+		
Field Usage			+			+
Producing costs	+				+	
Multi-user Access			+	+		
Multi-purpose Usage			+	+		
Endurance			+	+		

the GUI was equipped with an array of attractive graphical and pictorial elements such as basic & modified Flash™ objects (Watrall, Herber et al., 2002, Watrall, Herber et al., 2006), high-resolution images, and anti-alias texts.

whole key process was maintained by a set of .swf files loading and unloading with respect to the user’s response.

The main user interface contains four compartments, the front-end interface, and three ‘pages’, namely, Coral Tour, Information and Guidelines pages. These pages were built as separate Flash™ scenes (Fig. 2A). The graphical, navigational & script elements of each scene were arranged into separate layers (Fig. 2B).

The loading and unloading process of the key-process elements were made to operate on two different levels.

### Designing the Key Process

Similar to that of its conventional counterpart, the key process of the computer assisted coral identification system represents the Polychotomous nature of the coral identification key. All steps of the Polychotomous coral identification key were digitally processed and stored as a set of .swf files. But unlike the conventional key, the GUI does not view all the key-steps (option sets) in one view. Instead, these .swf files containing the identification steps were assigned load-unload actions. In other terms, as the user advances along the process, the key- steps (option sets) were allowed to progressively load on to the GUI. Loading of new key-step results in unloading of the previous key-step from the GUI. Therefore, the



Figure 2. A: The Scene palette showing the four scenes of the Main UI, B: Layered arrangement of objects in a scene (Coral tour) of the main UI

The key process interface was designed as single scene, containing navigational and background elements. This key process interface operates on the ground level of the flash movie, alternatively known as Level-0, which is the level which defines the stage size, background colour and frame rate of all the other levels (Bhanganal, 2001). But the .swf files containing the key-steps are loaded one level above level-0; which is level-1. Thereby, the loading and unloading of the key steps does not have any influence on the objects of Level-0 (Fig. 3A).

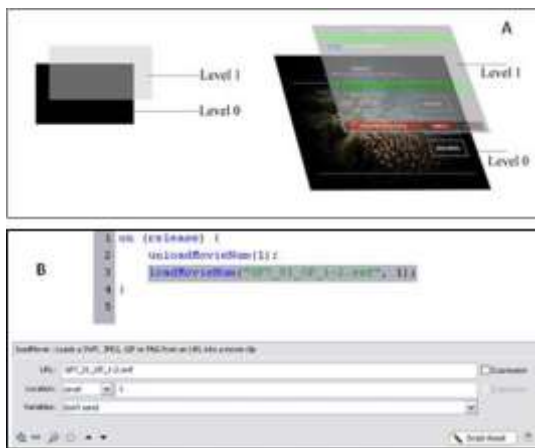


Figure 3 A: Overlay of Multi-level loading windows. Level 0 always refers to the background level. The key-process elements load in Level 1, which is above Level 0, B: Actionscript 2.0 syntax for multi-level loading windows (Bhanganal 2001). The bottom image shows the script in script assistant mode.

**Establishing connections and links**

Scenes, keyframes, movieclips and .swf files were interconnected using navigation objects. These navigation objects were designed as two types; buttons and links. Simple Actionscript commands were used to establish connections between related elements (Fig. 4).

```

1 on (release) {
2     gotoAndStop("Coral tour 1", 1);
3 }
4

```

Figure 4. A simple gotoAndStop action assigned to a button. This action links a button to a Scene. B: Interactive Glossary; An array of labeled key frames standing for scientific terms beginning with letter “F”

**Species fact sheet & Glossary element design**

Details of the coral genera (species fact sheets) which can be identified by the Computer Assisted Coral Identification System were designed as separate scenes. The identification pathway of a particular coral genus was ultimately linked to its fact sheet.

The Interactive Glossary, which was designed to provide descriptive information on scientific terminology, was created using scenes and keyframes. A single scene was created to accommodate all the scientific terms appearing under each alphabetical letter. Within each scene, descriptive information on each term was included in a separate keyframe event.

Each keyframe was labeled for quick recognition and these frame labels were eventually linked to their respective text-links (Fig. 5).

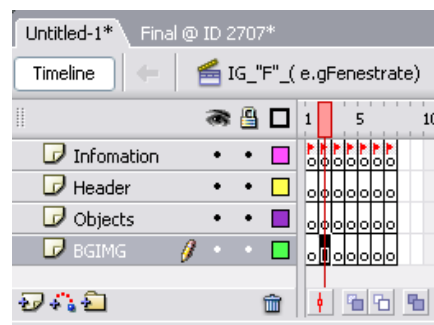


Figure 5. Interactive Glossary; An array of labeled key frames standing for scientific terms beginning with letter “F”

**Establishing security and privacy**

A log-in security system was established to prevent unauthorized access to the software. For any user to log in to the software, a 16 digit password is required. An input text field & a simple conditional statement were used to establish this access control.

**Generation of the output files**

External files required to properly run the software were organized in separate folders (Fig. 6). Finally, all the flash scenes, keyframes and objects were compiled to an executable (.exe) file (Fig. 7). This

could be launched from Microsoft™ Windows® based systems.

**The output package**

The Computer Assisted Coral Identification System was designed as it could be installed on Microsoft Windows based systems. All the necessary files were compressed and compiled to an install engine. An attractive autorun application was also created using commercially available autorun software. Finally, these files were written to DVD for distribution.

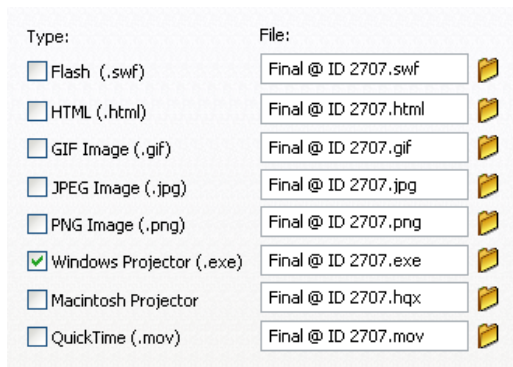


Figure 6. Organizing hierarchy of files and folders within the install engine.

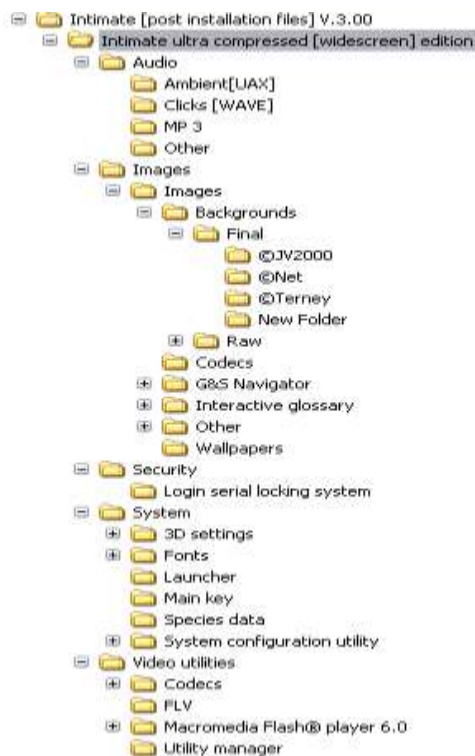


Figure 7. Processing of the final executable (.exe) file for Windows™ projectors

Direct Disc Labeling™ technology was used to create labels for the Disc. Eventually, an attractive and protective external package was designed to store and distribute the software.

**Results and Discussion**

**Preliminary survey**

The preliminary survey was carried out to find out the issues and constraints of the conventional species identification keys (including corals). The ideas generated by the respondents were used as the primary basis upon which the conventional coral identification key was modified. Out of 34 respondents, 22 (64.70%) suggested that they need help and assistance (of an expert) to successfully complete the identification process with the conventional species identification key. Respondents also suggested several issues of the conventional identification keys, which are, Long and complex key procedure, complexity of the scientific terminology, field usage difficulties, high chance of occurring personal errors, and the lack of visual elements. 46.15% of the respondents highlighted the long and complex key procedure as the main issue of interest (Fig. 8A). Most importantly, a vast majority of the respondents 94.11% suggested that the conventional identification keys need to be modified. Respondents also suggested four major areas where the conventional keys could be modified.

These are key procedure modifications, providing descriptive information on scientific terminology, use of more visual elements, and field-usage modifications. A majority of the respondents (42.86%) suggested that the key procedure has to be modified. An equal number (23.81%) of responses were recorded for field usage modifications and the use of descriptive scientific terminology (Fig. 8B). The issues highlighted by the respondents of the survey could be defined in to two broad categories, as field usage issues and user-friendliness issues (Table 1). Because all the other issues (lack of scientific descriptions, long and complex key procedure, low visual element support etc;) except difficulties of field usage contribute to generate a negative image on the user, thus reducing the user friendliness. Furthermore, all aspects of user friendliness issues could be addressed in one approach.

**Main features of the Computer Assisted Coral Identification System**

The ultimate result of this study was the development of Computer Assisted Coral Identification System.

This system was designed to address the user-friendliness issues of the conventional coral identification key. It is desirable to express the way

***An encouraging working environment***

attractive and encouraging by increasing the

by which the issues and constraints were addressed by the computerized design.

The environment in which the user is allowed to complete the identification process was made

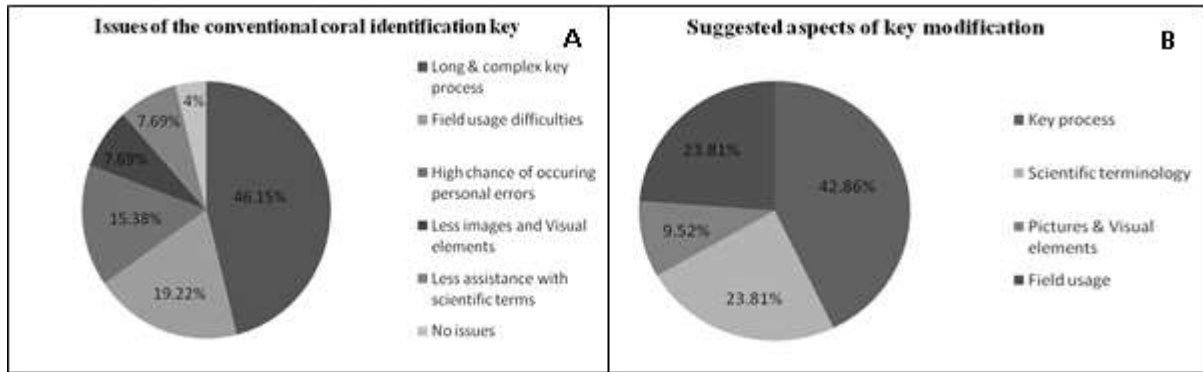


Figure 8. A: Summarized responses for identifying issues and constrains, B: modifying the conventional coral identifying key

amount and quality of the graphical/visual elements & designing effective navigational controls with Computer Assisted Coral Identification System.

***Descriptions for scientific terminology***

Complex scientific terms encountered within the coral identification process are explained by the Interactive Glossary (Fig. 9C).

The glossary was designed to provide explanations to scientific terms via information & pictorial interpretation.

***Empowered post identification procedure***

The conventional coral identification key does not provide any descriptions, details or images of the identified coral taxa. But the Computer Assisted Coral Identification System provides a brief description with pictures of the coral genera identified by the user (Fig. 9A).

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**Conclusions**

This study was carried out to achieve two main goals; to understand the issues and constraints of the conventional method of species identification and to work out a practicable solution to address all or some of the above issues.

The findings of the preliminary survey were used as the basis upon which the conventional model was modified. Respondents of the survey suggested numerous issues of the conventional coral identification key and they also highlighted the possible areas of the key where further improvisation was necessary.

Two main issues of the conventional coral identification key were identified; field usage issues and the lack of user friendliness. Both these issues could not be addressed in a single solution. Since most of the respondents highlighted the user friendliness issues as the prime issue (Fig. 8A), and the resource requirements for addressing it were quite low, user friendliness issues were selected to be addressed during this study.

A computer assisted system (software) was developed to increase the user friendliness of the

coral identification model. This system was designed to use the existing knowledgebase of the

But numerous modifications and improvisations were incorporated to the above computational model. Modifications were made to two main areas; the modification of the key procedure and modification of the working environment.

Descriptive information on scientific terminology is provided to the user via the Interactive Glossary. Furthermore, the post identification environment

coral identification key as its operating platform.

was empowered by providing information of the coral genera identified by the user.

These modifications were made with the intention of increase the user friendliness of the computer assisted model by, eliminating the complexities of the key procedure, creating an encouraging & attractive working environment and using more information with enhanced visual elements in the

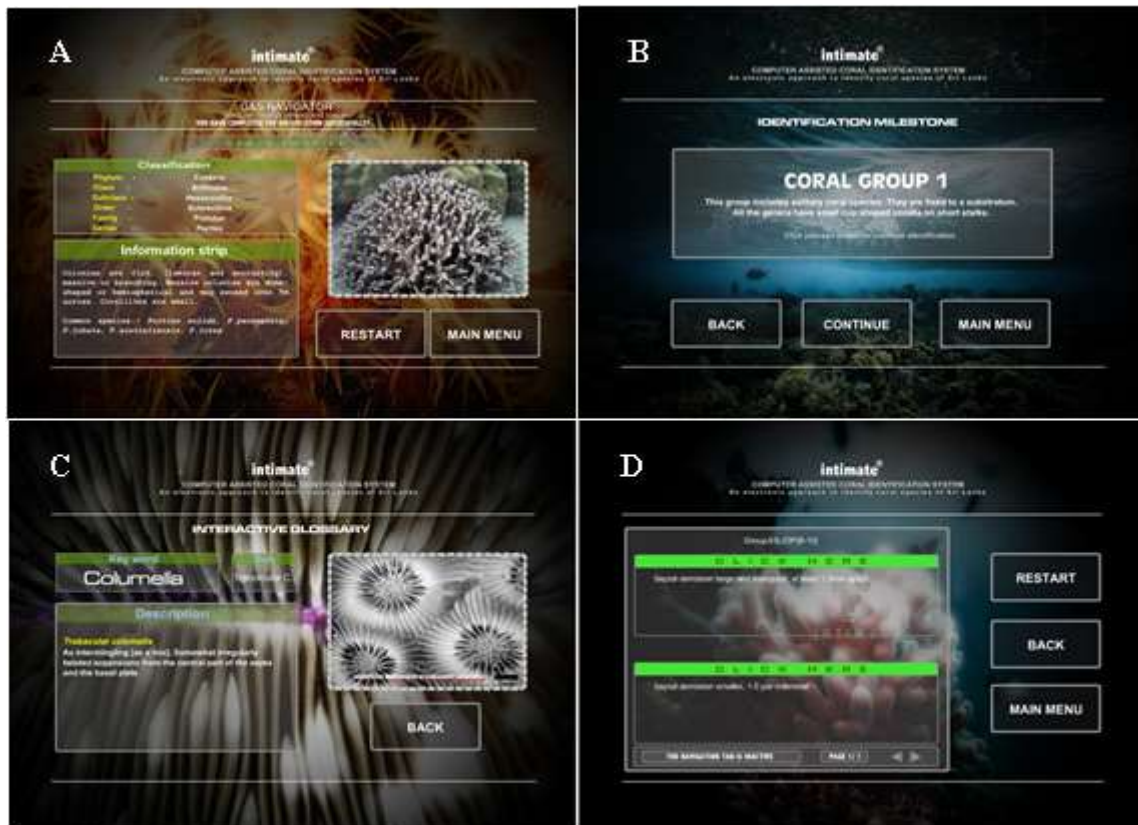


Figure 9: Features of the Computer Assisted Coral Identification system. A- Species fact sheet, B- Coral group identification milestone, C- The Interactive Glossary, D- Key process showing an option set.

Apart from being user friendly, the computer assisted model is believed to possess numerous accessory benefits. Relatively low production costs, ensuring data security, prevention of unauthorized access and multi-purpose usage (i.e. presentations) are among those benefits.

Although the Computer Assisted Coral Identification might be successful in overcoming the difficulties, issues and constrains of the conventional coral identification key, wider application, continuous monitoring, product evaluation & product modification will help to improve the user friendliness in the future.

identification process.

Such modifications would include, making necessary modifications in key procedure, including more pictorial elements, modifying user interfaces and use of new functions and computer tools.

The Computer Assisted Coral Identification System currently provide identification platform up to Generic level only (123 coral genera). But in future this system can be developed to identify coral specimen up to their species levels.

Also, it could be highlighted that a product evaluation survey could be carried out to uncover



the extent to which this solution satisfies the user-friendliness.

But such a study will have to be recessed until the Computer Assisted Coral Identification System is widely practiced in the coral identification process.

This study only concerns the lack of user friendliness as the target issue, leaving behind the field usage issues (which were not addressed due to practical difficulties) which are yet to be addressed in a separate study. Finally, it has to be emphasized that all the issues & constrains of the conventional coral identification key can only be addressed if both field usage and user friendliness issues are addressed together. Nevertheless, the Computer Assisted Coral Identification System can be proposed to use as a strong platform upon which further modifications to the conventional methods of species identification could be made.

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