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The unknowns in coral disease identification: An experiment to assess consensus of opinion amongst experts

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Abstract: As coral diseases have emerged as a leading cause of mass coral mortality, programmes to research and monitor them have increased. The resultant need to rapidly identify diseases has led to many studies relying on visual analysis and identification of disease. Such approaches have been criticised as subjective and lacking consistency. This study aims to test the level of consistency amongst disease experts by assessing their identification of diseases from a series of photographs. A high degree of variability in almost every photograph was found, with level of observer expertise having no apparent bearing on consistency. It is argued that in order for long term prevalence studies to have meaningful conclusions, standardisation is essential, with recently published coral disease identification guides being a vital step.

Keywords: Coral Disease, Identification

Introduction

Alongside climate change and overfishing, coral diseases are one of the most commonly implicated causes of mass coral mortality (Richardson 1998, Hoegh-Guldberg 1999, Harvell et al. 1999). While partial and whole-colony coral mortality from diseases can act as a natural and sustainable disturbance on coral reefs (Bythell et al. 2000), diseases have in some cases led to long-term, ecosystem-scale impacts. For example, White Band Disease has been implicated in the loss of acroporids as the dominant reef builders in the Caribbean, an unprecedented change within the past 3000-7000 years (Aronson and Precht 2001). Large-scale coral mortality has notable economic impacts for communities reliant on reefs for tourism, fishing and physical protection (Cesar 2002), whilst also contributing to potential phase-shifts and the reduction of reef resilience (Bellwood et al. 2004).

With such serious impacts, it is important that diseases are well studied so that effective management can take place. Yet, despite over 20 years of study, the drivers and dynamics of coral diseases are still poorly understood (CDWG 2007). Whilst it is widely agreed that increased temperature and nutrient enrichment may increase disease prevalence, there is debate as to whether pathogens are acting as primary infectious agents, or are opportunistic, taking advantage of reduced defences of stressed corals (Rosenberg et al. 2007; Lesser et al. 2007). Although over 35 diseases have been described (Lesser et al 2007), etiologies are only understood for five of them, despite considerable recent advances in microbiological techniques (CDWG 2007).

Compounding this lack of understanding is the confusion generated by a lack of rigorous standardisation in disease description and identification. Most monitoring studies do not have the equipment or expertise available for microbial analysis and therefore rely on visual identification (Ainsworth et al. 2007). However, such approaches can be highly subjective and result in errors, a lack of consistency between studies and misidentification (Work and Aeby 2006). Many disease identification guides only provide images of ‘classic’ well-defined disease symptoms, which means that field workers may not have the diagnostic tools to identify lesions displaying ambiguous symptoms. In these cases, many programmes will still require disease ‘identification’, perhaps forcing the observer to categorise disease cases with insufficient or confusing signs. Ainsworth et al. (2007) discovered that what appeared to be a white disease based upon visual morphological characteristics, actually had the microbial characteristics of Black Band Disease, demonstrating that, even aside from subjective errors, visual identification can be unreliable. Regional differences in nomenclature also contribute to variation. For example, swollen pink spots on *Porites* may be called *Porites* trematodiasis in Hawaii, pink spot in Australia, and *Porites* pink blotch disease in Okinawa (Aeby 2006). Highlighting this issue, Richardson (1998) notes that that several coral disease investigators studying an area of reef at the same time named a number of different diseases whilst diagnosing lesions on the same coral colonies.

Recognising the critical nature of accurate field identification, calls have been made to standardise the descriptors of coral syndromes and develop systematic approaches to lesion classification. To this end, Work and Aeby (2006) developed a set of criteria based on the morphological characteristics of a lesion that can be used to describe a syndrome. The most recent system is a handbook and sets of disease identification cards produced by the Coral Disease Working Group (CDWG) that utilise a systematic 'decision tree' approach. This guide is intended to form a standardised guide to identifying, assessing and managing coral reef disease, by providing managers and field surveyors with procedures for describing signs and assessing impacts and giving a standardised approach for recording coral health.

In light of the current debates regarding the best way to monitor coral diseases and the accuracy of visual identification, there is a need to assess the degree of consistency between observers. Therefore, this study aimed to investigate the usefulness of, and provide quantified data on, the level of consistency there is amongst coral disease experts. Using a number of photographs showing a range of coral lesions from different regions, the variation in disease names attributed to each lesion was tested, as well as the extent to which level of expertise affected agreement.

Methodology

The study was conducted through a poster presentation at the 11th International Coral Reef Symposium, Fort Lauderdale, from July 7th to 11th, 2008, as this was where the highest number of disease experts would be present at one time. The poster displayed 23 photographs (Appendix I) showing a variety of coral lesions from the Caribbean and Indo-Pacific regions, but the photograph location was not revealed. One colony photograph of each lesion was displayed and where necessary, an additional close-up showing the polyps was provided. Although it was impossible to select photographs randomly, bias towards 'classic' symptoms, or especially ambiguous samples was avoided and the lesions were chosen for the quality and clarity of the photographs alone. None of the lesions selected had been diagnosed, so there was no 'right' answer to aim for. The images were sourced from the archives of individuals at Newcastle University, UK.

Delegates visiting the poster who had experience of studying diseases were invited to study the photographs and name the disease as best they could. If they were unable to identify the disease, they were advised to leave it blank. The only variable was the level of expertise and respondents were asked to mark one of the five options shown in Table 1. In total, 94 surveys were conducted.

The results were collated according to three different protocols. Firstly, respondent answers were recorded word for word, giving a total of 83 unique descriptions. Secondly, unusual descriptions which had not been heard of were entered into the internet search engine Google Scholar. All descriptions that were not found in publications or monitoring studies were regarded as guesswork and thus re-categorised as 'guess'. Finally, the descriptions that were not a published name, but could reasonably be assumed that the respondent meant a specific disease were grouped into the recognised category. This final data set was analysed in the results.

Table 1: Options for level of coral disease expertise.

1. You have encountered the subject during a short period of academic study or through a brief encounter whilst in the field.
2. You have a couple of weeks experience working on projects in the laboratory or field that have involved disease identification.
3. You have worked on a longer term project(s), encountering a variety of diseases and may have contributed to reports on the topic.
4. Your focus is not coral disease, however, you have spent sustained periods studying coral disease and have produced reports/published on the topic.
5. You have focussed your research in the field of coral disease for a number of years and have published extensively on the topic.

Results

Overall, there was a high variability amongst the respondents when assigning disease descriptions to each photograph, with no photograph receiving less than three descriptions and most receiving over eight (Fig. 1).

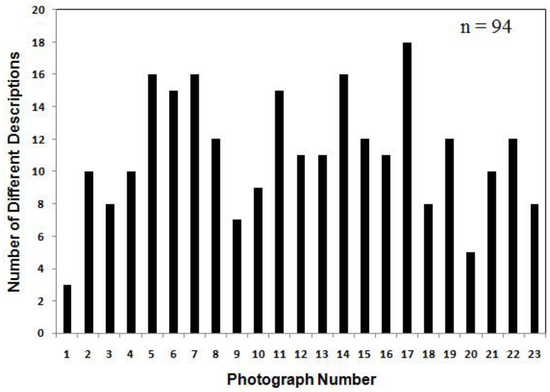

Figure 1: The number of different descriptions assigned to each photograph by whole sample.

This high variability in assigning descriptions to each photograph was also evident within the group of least experienced coral disease experts, with no photograph receiving less than three descriptions and most receiving more than five (Fig. 2). Photograph 17 was assigned eleven different descriptions by respondents, which represents more than one response for every four respondents.

Few signs are shown that consistency of response increases with level of coral disease research experience (Figs. 3 and 4). Despite the sample sizes being lower for the two groupings of respondents with higher levels of coral disease experience there is rarely an increase in response consistency. For instance, the group with most expertise had the highest variance of response for Photograph 5, whilst the group with the least expertise had the lowest variance (Fig. 2). For this photograph those with least expertise (levels 1 and 2) provided approximately one different response for every five respondents, whereas the most experienced (levels 4 and 5) provided a different response for almost every other respondent (Fig. 4). The most experienced respondents also returned a greater number of descriptions than the least experienced group for Photographs 2, 5 and 12, but were most consistent for Photographs 1, 3 and 20.

The spread of disease descriptions for each photograph is shown in Appendix II (Tables 2 and 3).

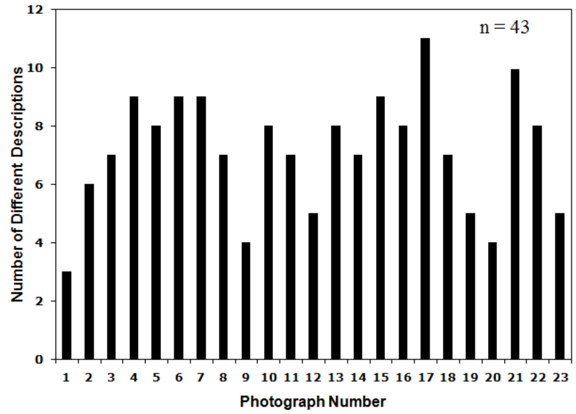

Figure 2: The number of different descriptions assigned to each photograph by respondents - expertise levels 1 and 2.

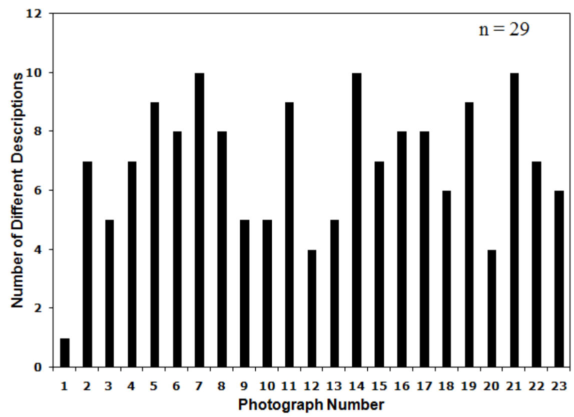

Figure 3: The number of different descriptions assigned to each photograph by respondents - expertise level 3.

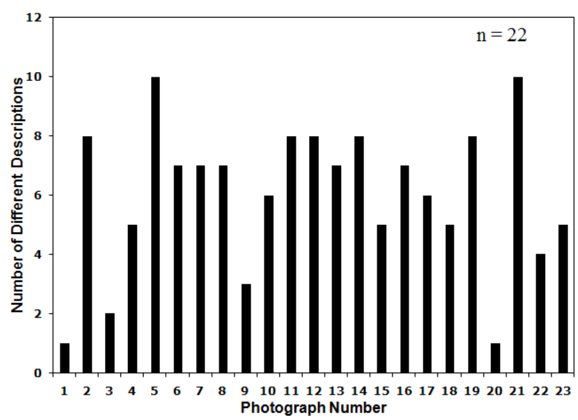

Figure 4: The number of different descriptions assigned to each photograph by respondents - expertise levels 4 and 5.

Some photographs received more consistent overall responses, such as Photograph 1 where 82 of the 94 respondents identified BBD, others identifying brown band and red band (Table 2). Confusion here would appear to be narrowly defined between a range of band diseases, but looking at Photograph 10, it can be seen that confusion can be wider ranging. For this photograph, the most popular responses were bleaching, fish predation and white plague, three syndromes with very different causation (Table 2). Photograph 13 shows that this was also present for the most experienced respondents. In this photograph, experienced respondents were heavily split between a number of white diseases and the very different causation of various predations (Table 3).

Discussion

This study demonstrates that there was a considerable lack of consistency amongst observers when identifying lesions visually. The reason behind such differences is unclear. This could be explained by regional differences in terminology, which are acknowledged to be common (Aeby 2006), and were evident in the initial high number of descriptions. However, this is unlikely to have influenced the final results, as the methods used grouped the similar descriptions in specific categories, which were designed to eliminate such effects as far as possible. The presence of such regional variation raises the question of whether individuals recognise that they are using different names, or whether they regard the different names as different syndromes entirely.

The level of observer expertise did not have a consistent effect on the outcome, so misidentification due to inexperience does not fully explain the results. Although in some cases the more experienced respondents agreed entirely on a specific case description, in others they produced a higher number of descriptions than the least experienced observers. A high degree of variation between observers was therefore likely to be a result of subjective misinterpretation of the information in the photograph, whereby individuals weight syndrome characteristics differently and thus interpret photographs differently.

It is possible that results could have been influenced by how recently an individual was monitoring disease, or by their geographic location. Researchers are more likely to be able to identify diseases in taxa they are familiar with and respondents attempting to identify lesions from unfamiliar regions may explain some of the variability. It is also possible that respondents misrepresented their level of experience, but further study would be required to give clearer answers.

It should be noted that in the field, observers are often looking for a specific set of diseases predefined using histological and microbial tools and will also have more information available than in a two-dimensional photograph, which would probably give *in-situ* observations higher consistency than our results. Also, if using photographs, observers would often have more than one colony photograph providing information, which may improve consistency.

However, it is clear that although the variance of descriptions increases with experience in a few cases, the results strongly suggest that increased training is not the best solution to improve consistency. This highlights the need for standardisation globally, as argued by Work and Aeby (2006). A global standard would go some way to eliminating this variation and reducing the number of descriptions for the same disease.

The results also suggest sizeable problems with attempting to measure disease prevalence changes over time or in larger scale meta-analysis studies. However, progress is being made towards improving this situation and the publication of disease ID guides by the CDWG (2007) offers the beginnings of a solution. If there is widespread adoption of the identification protocols, the likelihood of the misinterpretation and subjective weighting of the importance of lesion characteristics will be reduced and conclusions drawn from monitoring data much more useful for regional and global comparisons. Although such guides will be useful for standardising terminology and field identification, there now need to be studies assessing consistency of identification by observers in the field (i.e. of randomly-selected and representative cases, rather than 'type' cases).

Acknowledgments

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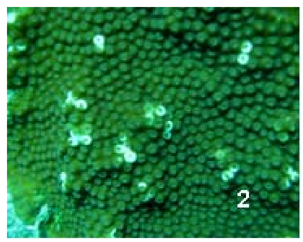
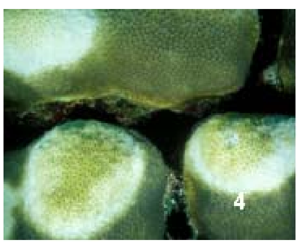
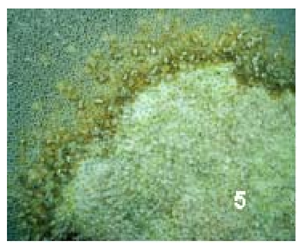
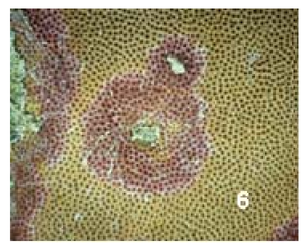
Appendix I

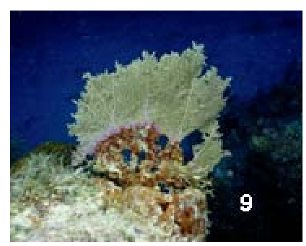
The following 23 photographs are the photographs shown to the respondents in this study. The number assigned to each image is the same as in the original study, thus relate directly to the numbers in all figures and tables in this paper. The images labelled ‘b’ represent the additional close-ups provided to respondents, where polyps were considered to be hard to identify on the primary photograph.

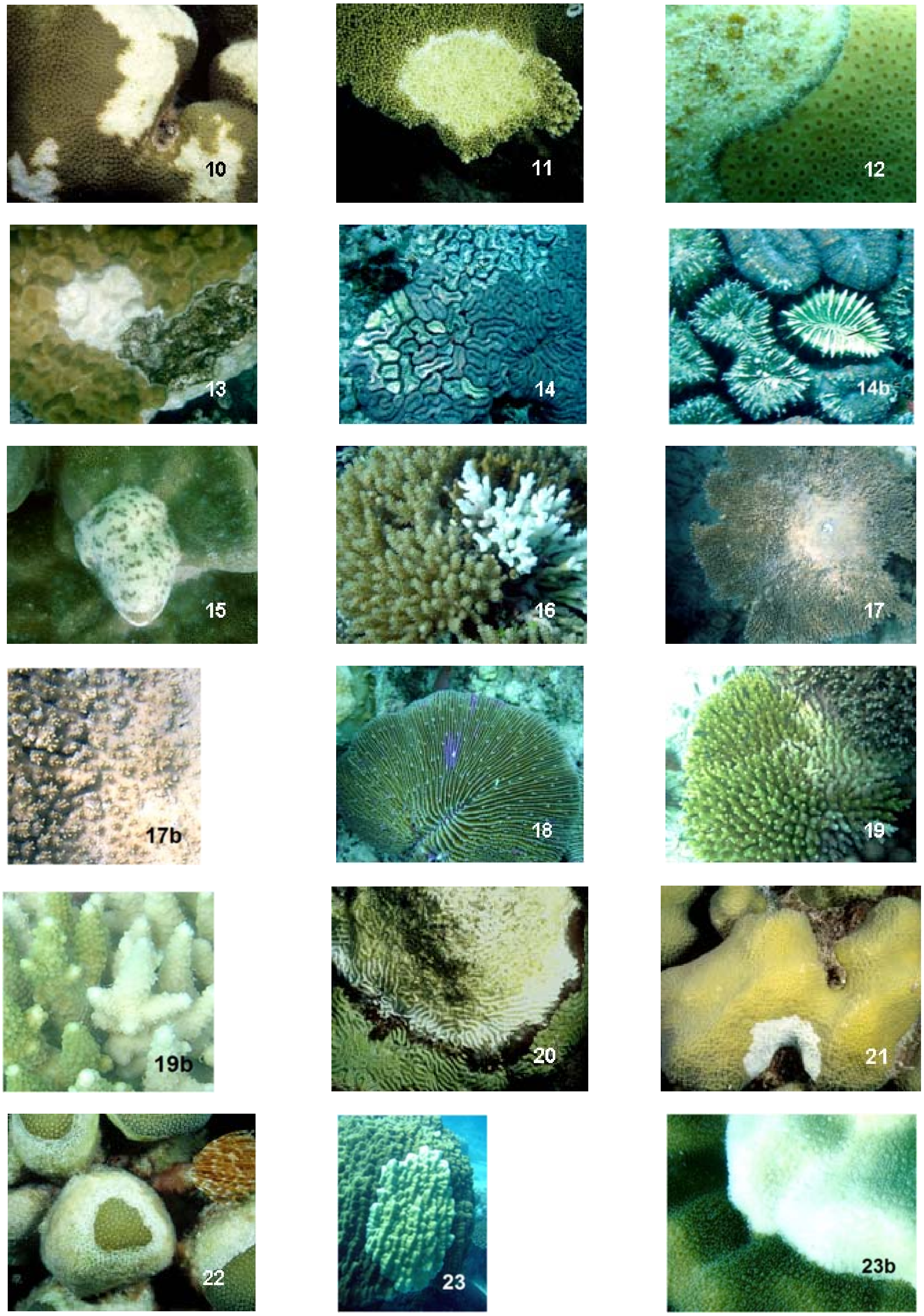








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Appendix II

Table2: Total number of responses per identified description for each photo. Matrix for all respondents.

Disease Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Abrasion		1				1	1							2			1						
Aggressive Overgrowth			2		2	1	5		1			2	4				1		1	1		1	
Aspergillosis						1			56									3					
Atremientous Necrosis					1		1										1						
Black Band	82				2	1	1					41					1	1		72	1	1	2
Bleaching		7	2	14	2			8		11	3	2	4	3	19	35	2		17	1	3	2	13
Brown Band	2				5	2					1									3			
Ciliates					2							7			1								
Compromised Health					1												1						
Coraline Lethal Orange					1																		
Crown of Thorns					1						1		2	1		5	2						1
Cyanobacteria				1					4														
Damsel Fish Feeding					7						1												
Dark Spot						32	1					1						3					
Fish Predation		21		1			3		1	27	1	1	10		8	6	2		5		4	2	
Focal/Patchy Bleaching		5													3				1		2		2
Fungal Overgrowth					1				1			1	1	1			1	3					
Growth/Sketal Anomoly		1					5				1			1	1		13						4
Guessed Answer		2				2	1	1				1		1		1	1						
Invert Colonisation				1				1				1		1	1	2			2		5		
Menanisation						1																	
No Disease Displayed		8				1	2							3			6	6	1				
Pigment Response						1	1											18					
Pink Spot						5												1					
Purple Spots						6			1									8					
Rapid Tissue Necrosis				1				2					2	1	1	1						1	
Rapid Wasting														1								1	
Red Band	4				7	8			10					1						2			
Sediment Mortality							3						1				5					1	
Shut Down Reaction																2			2			2	
Skeletal Eroding Band							1	1				7		1									
Tissue Loss			1				4	1		2	2		2	9	2		1		1		1		
White Band			33	10				1		1	13		1			2	2		5		4	11	3
White Disease										3	2					1							
White Plague			30	20	1		1	17		15	10		14	2	7	5			3		31	31	24
White Pox		7						2		4	16				1		1		1				
White Spot		10								1	1			1	2								
White Syndrome		4	7	11	1	1		6		6	5	1	8	7	5	6	1		9		4	9	7
Yellow Band			3	8	17	1	5	10			1						1				1		
Yellow Blotch			1	6	5		1	1			3											1	

Table 3: Total number of responses per identified description for each photo. Matrix for respondents whom were most experienced in coral disease research (levels 4 and 5).

Disease Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Abrasion							1							1									
Aggressive Overgrowth					1							1	2						1				
Aspergillosis									12														
Atremientous Necrosis																							
Black Band	21				1							4								20			
Bleaching		2		4	1			4		1	1	1	1	1	8	8	1		3			1	2
Brown Band						1																	
Ciliates					1							7											
Compromised Health					1												1						
Coraline Lethal Orange																							
Crown of Thorns					1								2	1		1							
Cyanobacteria									3														
Damsel Fish Feeding					6						1												
Dark Spot						13												1					
Fish Predation		8	0				1			13		1	4		5	2	1		3			1	
Focal/Patchy Bleaching		1													1				1				1
Fungal Overgrowth												1						1					
Growth/Sketal Anomoly		1					1				1						8						3
Guessed Answer		2												1			1						
Invert Colonisation								1								1							
Menanisation																							
No Disease Displayed		3				1								1				2					
Pigment Response						1												10					
Pink Spot						1																	
Purple Spots						2												2					
Rapid Tissue Necrosis																							
Rapid Wasting																							
Red Band						1			5														
Sediment Mortality							2						1				1						
Shut Down Reaction																							
Skeletal Eroding Band							1					4											
Tissue Loss							1							2									
White Band			3								2								1				
White Disease										2	2												
White Plague			17	6				5		2	2		3	1		1			1			12	7
White Pox		1						1		1	9								1				
White Spot		1													1								
White Syndrome				5	1			3		1	1	1	6	4	2	3			6			1	6
Yellow Band				2	3		3	2															
Yellow Blotch				3	1			1															