Coral Reef Fish Diversity

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Chapter 2

Coral reef fish diversity

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SUMMARY

- An underwater survey to study the diversity of coral reef fish was undertaken on 48 sites spread over the three communes of Touho, Poindimié and Ponérihouen in Province Nord. A total of 433 species of fish was identified. This value is less in comparison to the 1695 species reported to occur in the 0-100m zone of New Caledonia by Ron Fricke and Micheal Kulbicki.

- The number of fish species recorded during this RAP ranged from 39 to 143 for the least rich to richest site respectively. A mangrove site with only seven species and where no reefs were present was not taken into account in determining an average mean per site. The mean number of species per site was 83.36 for the 47 sites sampled.

- Over the area studied, the three most dominant families present were Labridae with 68 species, Pomacentridae with 61 species and Chaetodontidae with 29 species.

- The highest diversity coral reef fish was mainly observed on the outer reef slopes with an average of 113.57 species. The other habitats samples had mean values of species as: passes with 92.57 species; intermediate reefs with 87.31 species; back reefs with 85.66 species and fringing reefs with 50.25 species per site.

- The Coral Fish Diversity Index (CFDI) formula by Gerard Allen was applied for this study, allowing a more accurate count of the number of species. With more than 729 species presumed to be in this area, species richness was slightly lower than that of the two previous RAP surveys. This difference may be due to the lower average counting time of 70 min instead of 85 min during the previous RAPs. Also, the number of sites surveyed was fewer than for the Mount Panié and Koumac to Yandé RAPs. Many additional factors could explain these minute differences, like tides, different time of day, observer vision accuracy and others.

- One new fish, *Chlorurus japanensis* (Bloch, 1789) was observed, recorded and photographed for the first time in New Caledonia during this survey. The presence of *Halichoeres richmondi* Fowler and Bean, 1928, another species not listed in the official IRD inventory but previously recorded during the Mount Panié RAP by Richard Evans, is certainly confirmed by several observations. Additionally, ten other fish could not be identified; some may be new species.

- Overall, observations from this study indicate that majority of the fringing reefs are already damaged, host few fish and have a lower species diversity of fish. Fortunately, it appears that the greater majority of the barrier reefs and their surrounding areas show excellent fish diversity. Intermediate reefs were observed to have good to medium fish

diversity. Finally, this survey suggests the existence of a remarkable coral-reef fish biodiversity in this part of New Caledonia. Regionally, this area comparatively has a very good number of fish species.

INTRODUCTION

In this survey, the biodiversity of coral reef fish is used as an indicator of coral reef health. To this effect, coral-reef fish taxa represent a good proxy. They are easy to observe and constitute a large proportion of global reef biomass. Sites showing high levels of coral-reef fish diversity also generally have greater habitat diversity (Chittaro, 2004), another attribute of reef health.

Numerous established institutions in New Caledonia have studied coral-reef fish (SPC, IRD, IFREMER, Province Sud, Province Nord, UNC). Unfortunately, separation between commercial (targeted) species and others is often too variable from one study to another. Even among studies from recognised institutions, it is common to find lists that are quite different.

The aim of this study was to provide an overview of « baseline data » of what exists. This survey being the first carried out in this area, took into account all coral-reef fish without exception, with the goal of providing a complete list. Indeed, there exists many lists and most of them rarely treat the totality of fish that could be encountered during surveys. In this RAP, targeted (commercial) fish were recorded and observed by Maël Imirizaldu (Chapter 4). Generally they are large fish and more prone to be caught and/or sold in New Caledonia depending on local habits.

Authors such as Randall, Allen, Humann, DeLoach, Leiske and Myers all published books on coral reef fish in the Pacific, while Pierre Laboute also published many specific books on coral reef and fish of New Caledonia (Laboute 2000). New Caledonia is located on the Indo-Pacific tectonic plate, an area where a few regions host the world's highest coral reef fish diversity, namely 2500 species in Papua New Guinea (Lieske and Myers, 2001). The South-East Pacific region is recognised for having high speciesdiversity. The greatest number of species is observed on the Great Barrier Reef (approximately 1800). In comparison, a total of 1695 species occur in the 0–100 m zone in New Caledonia as reported by Fricke and Kulbicki (2006). New Caledonia is also recognized as a regional centre with high levels of endemism for coral reef fish (Olsen and Dinerstein, 2002; Roberts *et al.,* 2002).

METHODOLOGY

This study was conducted in two stages. The first part took place while on the catamaran Bayou, with all other experts participating in this RAP between November 16th and November 29th, 2009, for sites 1 to 30. The second part, sites 31 to 48, was finalized with assistance of Martin Ravana, manager of Tiete Diving Poindimié, onboard a semi-rigid from 29th January to 3rd February 2010.

The sampling effort over the different habitats of the study area is shown in Table 2.1.

Table 2.1. Site and habitat distribution over the three sampling zones

Habitats Types	TOUHO ZONE	POINDIMIE ZONE	PONERIHOUEN ZONE	Total
Fringing reef	12, 13, 15, 6	30, 35	46, 48	7
	Total : 4	**Total : 2**	**Total : 1**	
Mangrove	14	-	-	**1**
	Total : 1	-	-	
Intermediate reef	16, 17, 4, 5, 8, 9	29, 33, 34, 36	39, 40, 41, 42, 45, 47	**16**
	Total : 6	**Total : 4**	**Total : 6**	
Back reef	11, 18, 3, 7	22, 23, 24, 27	44	**9**
	Total : 4	**Total : 4**	**Total 1**	
Pass	10	19, 20, 25, 28, 32	43	7
	Total : 1	**Total : 5**	**Total : 1**	
Outer-reef slope	1, 2	21, 26, 31	37, 38	7
	Total : 2	**Total : 3**	**Total : 2**	

This coral-reef fish survey focused mainly on the following families : Muraenidae, Congridae, Synodontidae, Aulostomidae, Fistulariidae, Syngnathidae, Scorpaenidae, Anthiinae, Serranidae (*Belonoperca* et *Diploprion* only), Apogonidae, Malacanthidae, Echeneidae, Nemipteridae, Pempheridae, Chaetodontidae, Pomacanthidae, Pomacentridae, Cirrhitidae, some of the smallest Labridae (*Bodianus*, *Chelio*, *Cirrhilabrus*, *Coris*, *Cymolutes*, *Gomphosus*, *Halichoeres*, *Hologymnosus*, *Labrichthys*, *Labroides*, *Labropsis*, *Macropharyngodon*, *Novaculichthys*, *Oxycheilinus*, *Pseudocheilinus*, *Pseudodax*, *Pseudojuloides*, *Stethojulis*, *Thalassoma*, *Iniistius*), Penguipedidae, Blenniidae, Callionymidae, Gobiidae, Microdesmidae, Zanclidae, Bothidae, Soleidae, Balistidae, Monacanthidae, Ostracidae, Tetraodontidae et Diodontidae.

Coral reef fish are usually surveyed by using two separate lists: the “commercial fish” and the “reef fish”. These lists have been developed by institutions (IRD, SPC) over a series of largely regional ichthyologic studies (South West Pacific and Central Pacific).

The difficulty of establishing a list of commercial fish comes from fishing habits and consumption patterns which vary greatly from one region to another. A good example is one of « butterfly fish » (*Chaetodon*) that are regularly consumed in the Central Pacific but almost never in New Caledonia. In other words, a commercial fish in one region is often recognized in the list of reef fish in another region.

For this study, one of us, Mael Imirizaldu, was counting commercial fish while I was tasked to count reef fish. The fact remains that within a same family of fish, some will be included in the commercial group (normally the larger ones subject to regular consumption) and others (the smallest ones which are neither caught nor consumed) will appear in the list of reef fish. The problem is that there are often exceptions as mentioned above.

Therefore in order to better reflect the structure of coral reef fish communities and to allow for a better comparison with other studies of Conservation International, the two lists of all fish (M. Imirizaldu and P. Laboute) were pooled for data analysis. All fish surveyed were taken into account.

A rebreather unit was used in this study to better approach and observe fish; this apparatus emits no bubbles and is silent. Unlike SCUBA equipment where fish are scared by each breath the diver expires, here fish are not afraid at all. The rebreather allows for easy approach and observation of fish up close for as long as you want in order to clearly see specific morphologic details needed for identification.

Counting methodology consisted of random swims in zig-zag patterns from 30 m to 1 m deep for a mean dive time of 70 minutes.

Time counting fish varied according to three principal criteria:

- Variances in abundance and diversity of fish communities
- Fish behaviour, grouped and clearly visible or rather isolated from one another and more or less hiding around the bottom or in coral structures and often showing darkened hues
- Swimming distances and physical constraints such as currents

Fish counts were achieved using indices ranging from 1 to 4 (see Table 2.2). Relative abundance of fish as well as presence was noted at each site. If a species is observed only once on a site, its abundance index is 1 (rare), a score of 2 (occasional) is assigned when 2–10 individuals of a species are observed and a score of 3 (frequent) is granted for 11 to 50 individuals observed, and finally a score of 4 (abundant) is given when more than 50 individuals are seen. The average abundance curve for each species on all sites can be measured, which allows for the definition of an index of relative abundance or to describe each species present.

RESULTS AND DISCUSSION

With a total of 433 recorded species, our study represents just under 26% of the official survey of 2002 (a figure that is certainly a little higher today) carried out by the IRD that reported 1695 species in the depth range of 0 to 100 meters for all of New Caledonia,.

The total number of species observed in the present study appears low with several factors needing to be taken into account. These factors include our depth limitations (30 m instead of 100 m), the lack of observation in many facies during this RAP and only the use of a visual census.In consideration of these factors, this figure represents a good average. Indeed, to obtain a complete census, such as the one cited above, many techniques had to be carried out multiple times with invasive or detructive methods used (e.g net and line fishing and poisoning) for several sites over all environments (e.g. mud flats, sand, seagrass and algal beds) and in depths beyond 30 m.

Compared to the previous Conservation International Marine RAPs our total species count is low, the Mount Panié survey recorded 597 species in 2004 while the Koumac and Yandé survey recorded 527 species in 2009.

These differences may be explained by a little shorter counting times during this survey that did not allow traveling long distances, and poor to average states with very limited visibility especially on the fringing reefs.

Table 2.2. Abundance indices

1 =	1 individual
2 =	2 to 10 individuals
3 =	11 to 50 individuals
4 =	> 50 individuals

General fish community composition

The order of species richness form highest to lowest for the 10 families of reef fish surveyed in this area differs somewhat from that of Mont Panié survey. However, the first two families are the same and in the same order (Table 2.3).
The coral structures from one zone to another often show significant differences and it is not really unusual to find that the ranking for some families is somewhat different.

Fish community structuring

As expected and in general, outer reef slopes were observed to have the highest number of species, but some of these sites were outnumbered by intermediate reef sites, or by sites in the passes or by back reef sites (Table 2.4).

Some back reef sites and intermediate reef sites seem to have been more or less destroyed by previous cyclones, which may explain why they are relegated to the bottom of the ranking alongside the fringing reefs. These latter ones are the least well ranked apart from sa few exceptions. Many of them suffer from siltation due to mining sites nearby. Paradoxically, some others are in quite good condition and one of them is almost completely silted up, although no mine is operating in its sector.

Generally, the greater part of the lagoon is quite narrow between the coast and the barrier reef and often deep. The substrates of these deep areas range between a depth of 20 and 35 m consisting mostly of mud and sand. There, scleractinians are rare. Only a relatively few shallow reefs, are colonized by scleractinians and concentrate the vast majority of fish. In those deep areas, fish are quite rare and the species that are found present are ones associated with the sand or silt.

Comparison by facies

The outer slopes were observed to have the highest species richness for fish (Table 2.5), conferring with the majority of studies on coral reef environments. This is due to the presence of many coral species for which growth is favored by clear waters and offer many shelters for fish. In addition, the majority of planktonic nutrients are found offshore that provide food for many planktivorous fish.

As shown in the table below, it is somewhat surprising that fish species richness between passes, back reefs and intermediate reefs is not well differentiated.

Fringing reefs being relatively most impacted by terrigenous runoffs, usually have smaller corals and sometimes corals are absent. This explains the absence of many fish on some fringing reefs.

Table 2.3. Ranking by species richness for the 10 most abundant reef fish families

Rank	Family	Species richness	Mean relative abundance
1	Labridae	68	2
2	Pomacentridae	61	3
3	Chaetodontidae	29	2
4	Gobiidae	28	2
5	Acanthuridae	27	2
6	Scaridae	25	2
7	Serranidae	23	2
8	Lutjanidae	14	2
9	Blenniidae	13	2
10	Apogonidae	12	2

Coral Fish Diversity Index CFDI

The CFDI formula developed by Gerald Allen (1998) allows for the estimation of a total number of species in a given region from only six dominant families of reef fish. These families are: Labridae, Pomacentridae, the Pomacanthidae, Chaetodontidae, Acanthuridae and Scaridae (Table 2.6).

Indicator species for the health status of reef corals (Family *Chaetodontidae*)

Many fish feed on coral polyps and many of them belong to the family *Chaetodontidae*. As such, some of them are considered « indicators of the health of coral reefs ». When the corals are dead or rare, corallivorous fish are absent or very few. It is therefore normal to see in Table 2.7 that outer slopes are ranked highest for the number of species of *Chaetodontidae*, since many of them owe their survival to the abundance of corals present the outer slopes.

In this study we notice that the outer slopes are not always the richest in corals with some back reef sites, reef passes or intermediate reefs having more diversity (see Chapter 1). Therefore, the mean number of *Chaetodontidae* species increases as shown in Table 2.8.

Only fringing reefs, with one exception, are hardly colonized by corals and have very little *Chaetodontidae*.

Threatened species

Very few bumphead parrots fish, *Bolbometopon muricatum* were observed during the two sampling periods of this study. The spawning season usually taking place from November to February, it is therefore quite surprising to have seen so few. But we know from divers at Tieti Diving in Poindimié that groups of 30/40 individuals are regularly observed in this area. In our opinion they are still less abundant than in areas of Mount Panié and of the north-west, Koumac to Yandé.

We also note that the encounters with the classical *Carcharhinidae* (*C. albimarginatus* and to a lesser extent *C. amblyrhynchos*) were only marginal. Thirty years ago, in all areas, both species were common to every dive around the outer slopes and passes. We also note that the white tip reef shark, *Triaenodon obesus* is much less common in this area than in the lagoon and reefs southwest of New Caledonia.

Apart from one manta ray, *Manta birostris,* observed by the participants at site 43 and a black spotted stingray, *Taeniura meyeni* observed at site 5, we saw no other big sting ray such as *Aetobatus nari nari*, *Pastinachus Stephen*, or even

Himantura spp. Dugongs do not appear numerous in this area. Some turtles were observed, *Chaelonia mydas* and some rarer *Eretmochelys imbricata*. Dolphins (*Delphinidae*) were only rarely encountered.

New fish observations for New Caledonia

Two fish, *Halichoeres richmondi* and *Chlorurus japanensis*, which had been observed during the Mount Panié RAP in 2004 are widely confirmed in this study. They were observed, recorded and photographed. In addition, a *Pseudanthias* sp., four *Pomacentrus* spp., a *Cryptocentrus* sp., a *Ctenogobiops* sp. and three *Eviota* spp. were recorded and photographed. Some of them may be new species.

Table 2.4. Species richness ranking by descending order across all survey sites

Rank	Sites	Visibility	Biotopes	Species richness	Rank	Sites	Visibility	Biotopes	Species richness
1	2	17	Outer slope	**143**	25	40	12	Intermediate reef	**85**
2	17	7	Intermediate reef	**130**	26	23	7	Back reef	**84**
3	1	18	Outer slope	**128**	27	41	8	Intermediate reef	**83**
4	38	15	Outer slope	**125**	28	29	6	Intermediate reef	**83**
5	32	12	Pass	**108**	29	20	12	Pass	**81**
6	22	10	Back reef	**108**	30	7	8	Back reef	**80**
7	19	8	Pass	**107**	31	16	5	Intermediate reef	**80**
8	21	12	Outer slope	**106**	32	5	12	Intermediate reef	**79**
9	37	12	Outer slope	**105**	33	8	8	Intermediate reef	**76**
10	36	10	Intermediate reef	**99**	34	28	7	Pass	**76**
11	44	12	Back reef	**98**	35	18	15	Back reef	**74**
12	10	10	Pass	**97**	36	4	12	Intermediate reef	**73**
13	9	8	Intermediate reef	**96**	37	42	12	Intermediate reef	**71**
14	34	5	Intermediate reef	**96**	38	27	10	Back reef	**71**
15	31	15	Outer slope	**96**	39	47	10	Intermediate reef	**67**
16	3	5	Back reef	**96**	40	24	5	Back reef	**66**
17	39	10	Intermediate reef	**94**	41	13	4	Fringing reef	**52**
18	11	8	Back reef	**94**	42	48	5	Fringing reef	**51**
19	33	10	Intermediate reef	**93**	43	12	4	Fringing reef	**49**
20	45	8	Intermediate reef	**92**	44	46	3	Fringing reef	**43**
21	26	12	Outer slope	**92**	45	6	5	Fringing reef	**41**
22	25	12	Passe	**92**	46	30	5	Fringing reef	**40**
23	35	8	Récif frangeant	**88**	47	15	4	Fringing reef	**39**
24	43	12	Passe	**87**	48	14	5	Mangrove	7

Table 2.5. Mean species richness and mean number of families observed for each biotope. Values in parenthesis (Min-Max) represent the minimum and maximum values observed for each biotope.

Biotopes	No. of Sites	Mean species richness (Min-Max)	Mean number of families (Min-Max)
Outer slope	7	**103 (83-125)**	20 (17-24)
Pass	7	**84 (71-98)**	18 (16-21)
Intermediate reef	16	**82 (63-119)**	20 (13-26)
Back reef	9	**81 (66-97)**	20 (16-23)
Fringing reef	8	**47 (36-87)**	14 (9-20)
Mangrove	1	7	5

Table 2.6. Coral Fish Diversity Index (CFDI) for the Indo-Pacific region. The bold lines correspond to the Rapid Assessment Programs conducted by Conservation International in New Caledonia (this study included).

Localities	CFDI	Species richness observed	Estimated Species richness
Milne bay, Papua New Guinea	337	1109	1121,835
Maumere bay, Flores, Indonesia	333	1111	1108,275
Raja Ampat Islands, Indonesia	326	972	1084,545
Togean and Banggai Islands, Indonesia	308	819	1023,525
Komodo Islands, Indonesia	280	722	928,605
Calamianes Islands, Philippines	268	736	887,925
Madang, Papua New Guinea	257	787	850,635
Mont Panié lagoon, New Caledonia	**255**	**597**	**843,855**
Kimbe Bay, Papua New Guinea	254	687	840,465
Manado, Sulawesi, Indonesia	249	624	823,515
Northwest lagoon, New Caledonia	**234**	**527**	**772,665**
Capricorn Group, Great Barrier Reef	232	803	765,885
Ashmore reef /Cartier, Timor sea	225	669	742,155
Kashiwa-Jima Island, Japan	224	768	738,765
North-east lagoon (Touho-Ponérihouen), New Caledonia	**221**	**433**	**728,595**
Scott/Seringapatam reefs, Western Australia	220	593	725,205
Samoa Islands, Polynesia	211	852	694,695
Chesterfield Islands, Coral sea	210	699	691,305
Sangalakki Islands, Kalimantan, Indonesia	201	461	660,795
Bodgaya Islands, Sabah, Malaysia	197	516	647,235
Pulau Weh, Sumatra, Indonesia	196	533	643,845
Izu Islands, Japan	190	464	623,505
Christmas Island, Indian ocean	185	560	606,555
Sipidan Island, Sabah, Malaysia	184	492	603,165
Rowley-Shoals, Western Australia	176	505	576,045
Northwest Madagascar	176	463	576,045
Cocos-Keeling atoll, Indian ocean	167	528	545,535
Northwest Cap, Western Australia	164	527	535,365
Tunku Abdul Rahman Island, Sabah, Malaysia	139	357	450,615
Lord Howe Island, Australia	139	395	450,615
Monte Bello Islands, Western Australia	119	447	382,815
Bintan Island, Indonesia	97	304	308,235
Kimberley coast, Western Australia	89	367	281,115
Cassini Island, Western Australia	78	249	243,825
Johnston Island, Central Pacific	78	227	243,825
Midway atoll, Pacific, U.S.A	77	250	240,435
Rapa, Polynesia	77	209	240,435
Norfolk Island, Australia	72	220	223,485

Table 2.7. Mean species richness of *Chaetodontidae* and observation frequency of exclusively corallivorous species by biotope.

Biotopes	Mean number of *Chaetodontidae* species	Observation frequency of exclusive corallivores (%)
Outer Slope	9	74
Intermediate reef	8	61
Back reef	6	50
Pass	6	43
Fringing reef	5	35

CONCLUSION

This study suggests that the species richness and diversity of coral reef fish populations is quite good throughout the study area. This general notion, however, must be qualified. The findings revealed a total census of 433 fish species for the whole area. With corrections brought by the CFDI formula (Coral Fish Diversity Index) developed by Dr. Gerard Allen and based on only six key families, the number of fish species assumed to exist would be 729 species. This figure is quite similar (though lower) to the two previous Conservation International RAPs in the North Province of New Caledonia. At the regional level, the diversity of fish fauna in this area falls into a relatively high average. Greatest fish diversities were observed on the outer slopes on a fairly constant basis. For other facies, regarding passes, the back barrier reef and intermediate reefs, fish diversity is somewhat lower, but with large disparities between different sites. This

Table 2.8. Species richness ranking of *Chaetodontidae* by site (decreasing)

Sites	Biotopes	Species richness of *Chaetodontidae*	Number of exclusively corallivorous species observed
t1	Outer slope	11	3
10	Pass	10	5
17	Intermediate reef	10	2
33	Intermediate reef	10	3
36	Intermediate reef	10	4
5	Intermediate reef	10	4
2	Outer slope	9	3
27	Back reef	9	4
35	Fringing reef	9	4
37	Outer slope	9	4
4	Intermediate reef	9	5
24	Back reef	8	3
26	Outer slope	8	4
29	Intermediate reef	8	4
38	Outer slope	8	4
40	Intermediate reef	8	2
45	Intermediate reef	8	4
48	Fringing reef	8	2
9	Intermedaite reef	8	2
19	Pass	7	3
31	Outer slope	7	4
39	Intermediate reef	7	3
41	Intermediate reef	7	4
44	Back reef	7	3
8	Intermediate reef	7	3
12	Fringing reef	6	3
21	Outer slope	6	4
22	Back reef	6	3
42	Intermediate reef	6	4
43	Pass	6	0
20	Pass	5	3
3	Back reef	5	1
32	Pass	5	3
6	Fringing reef	5	2
34	Intermediate reef	4	3
46	Fringing reef	4	1
47	Intermediate reef	4	1
7	Back reef	4	2
11	Back reef	3	0
13	Fringing reef	3	1
15	Fringing reef	3	1
23	Back reef	3	2
25	Pass	3	1
16	Intermdiate reef	2	1
18	Back reef	2	0
28	Pass	2	0
30	Fringing reef	2	0

is in direct correlation with the state of the facies, sometimes in good condition or often more or less degraded (e.g. due to cyclones and cyanobacteria bloom). The lowest fish diversities observed were generally on the fringing reefs that are most often in poor condition (e.g. due to anthropogenic activity).

Labridae and Pomacentridae are by far the most diverse families observed, with respectively 68 and 61 species, distantly followed by the Chaetodontidae with 29 species. The inventory of fish in this area has confirmed the presence of two species that were not yet present in the IRD list, but which were reported during the Mont Panié RAP in 2004. These are the Labridae *Halichoeres richmondi* (Fowler and Bean, 1928) and the parrotfish *Chlorurus japanensis* (Bloch, 1789). Both were photographed and their identification cannot be doubted.

It should also be noted that ten indeterminate species were identified to the genus level. These included a *Pseudanthias*, four Pomacentridae (*Stegastes* and *Pomacentrus*), a *Cirripectes* and four Gobiidae (*Amblyeleotris* and *Eviota*). It is possible that two or three species are new to science. These fish were not caught, but only photographed.

The number of fish identified in this study, only by visual census, represent only about a quarter of the species recorded around all of New Caledonia between depths of 0–100 meters. A proper census uses many techniques, often very destructive. Also, despite the good condition of the reefs and the large number of facies here, this figure could be regarded as quite normal. Indeed, it is obvious that the time of counting does not always occur at the best time when the fishes will be most visible at each site. Fish activities are many and varied. By day, nocturnals are not seen, planktivorous only emerge when currents bring food particles and many of them become less visible as soon as they have eaten. All these reasons (and many others still) allow for considering this figure of 433 recorded species to be reasonable and fully acceptable.

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