An annotated list of fish parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda, Nematoda) collected from Snappers and Bream (Lutjanidae, Nemipteridae, Caesionidae) in New Caledonia confirms high parasite biodiversity on coral reef fish

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Abstract

Background: Coral reefs are areas of maximum biodiversity, but the parasites of coral reef fishes, and especially their species richness, are not well known. Over an 8-year period, parasites were collected from 24 species of Lutjanidae, Nemipteridae and Caesionidae off New Caledonia, South Pacific.

Results: Host-parasite and parasite-host lists are provided, with a total of 207 host-parasite combinations and 58 parasite species identified at the species level, with 27 new host records. Results are presented for isopods, copepods, monogeneans, digeneans, cestodes and nematodes. When results are restricted to well-sampled reef fish species (sample size > 30), the number of host-parasite combinations is 20–25 per fish species, and the number of parasites identified at the species level is 9–13 per fish species. Lutjanids include reef-associated fish and deeper sea fish from the outer slopes of the coral reef: fish from both milieus were compared. Surprisingly, parasite biodiversity was higher in deeper sea fish than in reef fish (host-parasite combinations: 12.50 vs 10.13, number of species per fish 3.75 vs 3.00); however, we identified four biases which diminish the validity of this comparison. Finally, these results and previously published results allow us to propose a generalization of parasite biodiversity for four major families of reef-associated fishes (Lutjanidae, Nemipteridae, Serranidae and Lethrinidae): well-sampled fish have a mean of 20 host-parasite combinations per fish species, and the number of parasites identified at the species level is 10 per fish species.

Conclusions: Since all precautions have been taken to minimize taxon numbers, it is safe to affirm than the number of fish parasites is at least ten times the number of fish species in coral reefs, for species of similar size or larger than the species in the four families studied; this is a major improvement to our estimate of biodiversity in coral reefs. Our results suggest that extinction of a coral reef fish species would eventually result in the coextinction of at least ten species of parasites.

Keywords: Biodiversity, Coral reefs, Parasites, Coextinction, Lutjanidae, New Caledonia, South Pacific
Background

Parasites probably constitute the least known component of biodiversity in coral reefs, which are considered some of the most diverse ecosystems on the planet [1]. An early evaluation of parasite biodiversity of fish of the Great Barrier Reef (GBR) in Australia proposed a number of 20,000 parasites (all groups included) in the 1,000 fish species believed to exist in the area at this time; however, this evaluation, published as short papers [2,3] was based on very limited data. More reliable estimates are available for only two groups, the digeneans and monogeneans. Estimates were 2,270 digenean species in the 1,300 fish species of the GBR [4] and 2,000 monogenean species on the 1,000 fish species recorded around Heron Island, in the southern GBR [5].

An eight-year program allowed us to investigate the biodiversity of fish parasites off New Caledonia (South Pacific), the largest coral lagoon of the world. A compilation of available literature including a number of papers produced by this program [6] concluded that only 2% of fish parasite biodiversity was known in New Caledonia. Two subsequent comprehensive papers provided abundant, previously unpublished data and a compilation of already published information on two families of fish, the Serranidae (groupers) and the Lethrinidae (emperors) [7,8]. In this paper, we provide information about the parasites of the Lutjanidae, Nemipteridae and Caesionidae and compare our results with those already published for the other families.

Results

Results are presented as a host-parasite list (Appendix 1), a parasite-host list (Appendix 2) and a list of material deposited (Appendix 3). The number of host-parasite combinations (HPCs) and the number of species-level identified parasite – host-parasite combinations (SLIP-HPCs) found in each fish species are given in Table 1.

Discussion

Comments on each group

For brevity, in this section references to our own published papers on these fish families (available in Table 2 and Appendix 2) are kept to a minimum. For parasites, the “minimized number of taxa” is a cautious minimized evaluation in which all unidentified taxa in a group are counted as a single taxon [8].

Fish

In this paper, we group results from three families of fish, namely the Lutjanidae, Nemipteridae and Caesionidae. Clearly, most of the results concern the Lutjanidae but we included the two other families because they are closely related [9-11]. Modern molecular phylogenies are available for the Lutjanidae [12-15] and confirm the close relationship of the Lutjanidae and Caesionidae.

According to the most recent survey [16], the Lutjanidae, Caesionidae and Nemipteridae include, respectively, 17, 4, and 5 genera and 108, 22 and 66 species, with a total of 26 genera, 196 species. The numbers of species in New Caledonia [17] are, respectively, 43, 13, and 16, with a total 72 species. In this work, we report parasitological results from 18 lutjanid species, 1 caesionid and 6 nemipterids; the total, 25 species, represents 34% of the species reported from New Caledonia, and 13% of the world number of species for the three families.

Diets of lutjanids and nemipterids off New Caledonia mainly comprise fish, crustaceans and occasionally molluscs [18], all of which can serve as intermediate hosts for parasites such as nematodes, digeneans and cestodes.

Most fishes included in this study are reef-dwelling; however, we also include several lutjanids (two species of Etelis and three species of Pristipomoides) which are deeper water fishes, collected from the outer slope of the barrier reef of New Caledonia [19]. These fishes provide data for a comparison of the parasitic fauna of coral-associated and deeper sea fishes.

As occurs often in the South Pacific, parasitologists have had to face problems with fish taxonomy [8,20-23]. Pentapodus aureofasciatus Russell, 2001, was first identified as Pentapodus sp. in the description of a nematode [24] but this was corrected later [25].

Isopoda

Adult isopods were rare and belonged to three families: Aegidae, Corallanidae and Cymothoidae. The single aegid, Aega musorstom, was found on a deep water lutjanid. Two cymothoids (Anilocra gigantea and An. longicauda) were found only on deep water lutjanids, but the single corallanid, Arthogona macronema, was found on a coral dwelling lutjanid. An. gigantea was already known from New Caledonia and was recorded from the branchial region of the deep water lutjanid Etelis carbunculus off “Banc de la Torche, au sud-est de la Nouvelle Calédonie” [26]. It was also recorded from the Pacific Ocean from the gills of Epinephelus sp. and Pr. flavipinnis, off Suva reefs, Suva, Fiji [27] and from the Indian Ocean from an unidentified host [28-30]. We found this species again on Et. carbunculus, but Et. coruscans and Pr. filamentosus are new host records. Interestingly, we did not collect this species from the branchial region or from the gills of the host fish, as reported by previous authors but on the anterior part of the body just behind the head. A female specimen of An. gigantea attached behind the head of Pr. filamentosus is illustrated by a colour photograph (Figure 1).

An. longicauda was already known from the Indian and the Pacific Oceans [30]. It was previously recorded...
from Swains Reefs, Great Barrier Reef, Marion Reef, Australian Coral Sea, North West Shelf of Western Australia, Krakatua, Indonesia [31], Singapore and Poulo Condor, Vietnam [29,31], Ragay Gulf, Pasacao and Mari-buyo Bay, Bohol Island, Philippines [27]. This species has been reported from Plectorhynchus goldmani, Diagramma picta and Priacanthus sp. [31]. Pr. argyrogrammicus is a new host record and New Caledonia is a new geographical record.

Aega musorstom was already known from New Caledonia, in the vicinity of Western New Caledonia including the Coral Sea region of the Chesterfield Archipelago and the Loyalty Islands, at depths from 475 to 615 m [32]. Only one fish association was noted, “Synagonopi sp. 1” probably a species of Synagrops (Acropomatidae) [32]. Pr. filamentosus is a new host record. Aragathona macronema was already known from New Caledonia [7,33]. It was previously reported from

Table 1 Number of host-parasite combinations (HPCs) found in 24 species of caesionids, lutjanids and nemipterids in New Caledonia

| Family and habitat | Fish species | Total | Gill | Abdo | Isop | Cope | Mono | Poly | Dige | Both | Tetr | Tryp | Nema | Other | Total |
|--------------------|--------------|-------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|
| Caesionidae        | Caesio cuning | 8     | 4    | 8    |      |      | 2    | 1    |      |      |      |      |      | 5     | 5(0) |
| Lutjanidae, reef-associated | Aprion virescens | 3     | 3    | 3    |      |      | 1    | 1    |      |      |      |      |      | 3(3) |
|                    | Lutjanus adetii | 5     | 0    | 5    |      |      | 2    | 1    |      |      |      |      |      | 4(2) |
|                    | Lutjanus argentimaculatus | 4     | 3    | 3    | 1(0) |      | 2(1) | 5(3) |      |      |      |      | 13(8) |
|                    | Lutjanus fulviflamma | 17    | 11   | 11   | 2(1) |      | 3(2) | 1(0) | 2(2) |      |      |      | 9(5)  |
|                    | Lutjanus fulvus | 2     | 1    | 0    |      |      | 4(2) |      |      |      |      |      |      | 4(2)  |
|                    | Lutjanus giberus | 2     | 2    | 1    | 1(1) |      | 1(0) |      |      |      |      |      | 2(1) |
|                    | Lutjanus kasmira | 16    | 12   | 12   | 1(0) | 6(0) | 5(2) | 1(0) | 1(0) |      |      |      | 15(2) |
|                    | Lutjanus monostigma | 0     | 0    | 0    | 1(1) |      |      |      |      |      |      |      |      | 1(1)  |
|                    | Lutjanus quinqueletus | 12    | 0    | 6    |      |      | 5(3) | 2(2) |      |      |      |      | 9(5)  |
|                    | Lutjanus rulatius | 2     | 2    | 2    |      |      | 1(0) |      |      |      |      |      | 3(0)  |
|                    | Lutjanus russellii | 6     | 0    | 1    | 1(0) | 4(2) | 2(1) |      |      |      |      |      | 8(3)  |
|                    | Lutjanus vitta | 42    | 19   | 31   | 1(0) | 6(2) | 5(3) | 1(0) | 2(2) | 5(2) |      | 20(9) |
| Macolor niger | 2     | 2    | 1    | 3(1) | 2(0) |      |      |      |      |      |      | 6(1)  |
| Lutjanidae, deep-sea | Etelis carbunculus | 16    | 5    | 3    | 1(1) | 4(1) | 1(1) | 3(2) | 1(0) | 1(0) | 2(1) | 1(0) | 14(6) |
|                    | Etelis coruscans | 18    | 11   | 5    | 1(1) | 4(1) | 2(2) | 1(0) | 3(1) |      | 1(0) | 2(2) | 14(7) |
|                    | Pristipomoides argyrogrammicus | 20    | 14   | 18   | 1(1) | 1(0) | 3(1) | 4(3) | 1(0) | 1(0) | 2(1) |      | 13(6) |
|                    | Pristipomoides auricilla | 2     | 2    | 2    | 1(0) |      | 1(1) | 1(0) | 1(0) |      |      | 3(1) | 8(2)  |
|                    | Pristipomoides filamentosus | 7     | 2    | 2    | 2(2) | 1(1) | 1(0) | 2(0) |      |      | 3(2) |      | 9(5)  |
| Nemipteridae       | Nemipterus furcosus | 239   | 111  | 160  | 1(0) | 2(0) | 1(0) | 5(4) | 1(0) | 1(0) | 6(6) | 7(3) | 1(0) | 25(13) |
|                    | Pentapodus aureofasciatus | 23    | 19   | 12   | 1(0) | 1(0) | 2(1) | 1(0) | 4(0) | 1(0) | 2(0) |      | 12(1) |
|                    | Pentapodus nagasakienis | 2     | 2    | 2    |      |      | 2(0) | 1(0) |      |      |      | 1(0) | 4(0)  |
|                    | Scolopsis bilineata | 12    | 8    | 9    | 1(0) |      | 2(1) |      | 1(0) | 1(0) |      |      | 5(1)  |
|                    | Scolopsis taeniaptera | 3     | 2    | 3    |      |      |      |      |      |      |      | 1(0) | 1(0)  |
| Total Caesionidae  | (1 species) | 8     | 4    | 8    |      |      | 2(0) | 1(0) | 1(0) |      |      |      | 5(0)  |
| Partial total Lutjanidae | reef (13) | 113   | 55   | 76   | 3(1) | 10(4) | 38(15) | 2(0) | 25(18) | 2(0) | 4(0) | 2(2) | 10(2) | 1(0) | 97(42) |
| Partial total Lutjanidae | deep-sea (5) | 63    | 34   | 30   | 6(5) | 10(3) | 8(4) | 1(0) | 13(7) | 0(0) | 3(0) | 4(0) | 12(6) | 1(0) | 58(25) |
| Total Lutjanidae  | (18 species) | 176   | 89   | 106  | 9(6) | 20(7) | 46(19) | 3(0) | 28(25) | 2(0) | 7(0) | 6(2) | 22(8) | 2(0) | 155(67) |
| Total Nemipteridae | (5 species) | 279   | 142  | 186  | 3(0) | 1(0) | 4(1) | 2(0) | 13(5) | 1(0) | 3(0) | 6(6) | 12(3) | 2(0) | 47(15) |
| Total (24 species) | 463   | 235  | 300  | 12(6) | 21(7) | 50(20) | 5(0) | 53(30) | 4(0) | 11(0) | 12(8) | 35(11) | 4(0) | 207(82) |

*: species with low sample size or only anecdotal collections, excluded from general calculations in Table 3. For each number: HPCs (SLIP-HPCs) i.e. number of host-parasite combinations, and, within parentheses, number of species level identified parasite – host-parasite combinations.
Table 2 List of 58 species identified at the species level with Latin binomial, with full authorities

| Class          | Family                        | Species Name                                      | Authors                                                                 |
|----------------|-------------------------------|--------------------------------------------------|-------------------------------------------------------------------------|
| Isopoda        | Aegidae: Aega musorstom       | Bruce, 2004                                      |                                                                        |
|                | Corallanidae: Argathona        | macronema                                       | Bleeker, 1857                                                           |
|                | Cymothoidae: Anilocra         | gigantea                                         | Herklots, 1870                                                          |
|                |                                | longicauda                                       | Schiede & Meinert, 1881                                                |
| Copepoda       | Caligidae: Caligus brevis     | Shiino, 1954                                     |                                                                        |
|                | Dissonidae: Dissonus          | excavatus                                        | Boxshall, Lin, Ho, Ohtsuka, Venmathi Maran & Justine, 2008             |
|                | Hatschekiidae: Hatschekia     | clava                                            | Kabata, 1991                                                           |
|                |                                | tansyma                                          | Ho & Kim, 2001                                                         |
| Monopisthocotylea | Lernaeolophus sultanus       | H Milne Edwards, 1840                            |
|                |                                | (H)                                              | Heller, 1865                                                           |
|                | Ancyrocephalidae: Haliotrematoide: Haliotrematoides lanx | Kritsky & Justine, 2009 in Kritsky, Yang & Sun, 2009 |
|                |                                | longitubocirrus                                  | Bychowsky & Nagibina, 1971                                             |
|                |                                | novaecaledonae                                   | Kritsky & Justine, 2009 in Kritsky, Yang & Sun, 2009                  |
|                |                                | patellacirrus                                    | Bychowsky & Nagibina, 1971                                             |
|                |                                | potens                                           | Kritsky & Justine, 2009 in Kritsky, Yang & Sun, 2009                  |
|                | Capsalidae: Benedenia         | elongata                                         | Yamaguti, 1968                                                         |
|                |                                | Lagenivaginopseudobenedenia                     | etelis Yamaguti, 1966                                                  |
|                |                                | Pseudonitzschia uku                              | Yamaguti, 1965                                                         |
|                |                                | Trilobiodiscus lutiani                           | Bychowsky & Nagibina, 1967                                            |
|                | Diplectanidae: Calydiscoides   | lima                                             | Justine & Brena, 2009                                                 |
| Digenea        | Acanthocolpidae: Pleorchis     | uku Yamaguti, 1970                               |                                                                        |
|                | Cryptogonimidae: Adlardia      | novacealedonae                                   | Miller, Bray, Goiran, Justine & Cribb, 2009                           |
|                | Cryptogonimidae: Euryakaina   | manilensis                                       | Velasquez, 1961                                                        |
|                | Cryptogonimidae: Euryakaina   | marina                                           | Hafeezullah & Siddiqi, 1970                                           |
|                | Cryptogonimidae: Metadena      | rooseveltiae                                     | Yamaguti, 1970                                                         |
|                | Cryptogonimidae: Retrovarium   | manteri                                          | Miller & Cribb, 2008                                                  |
|                | Cryptogonimidae: Retrovarium   | saccatum                                         | Manter, 1963                                                           |
|                | Cryptogonimidae: Siphodermia   | hiristicta                                       | Manter, 1963                                                           |
|                | Cryptogonimidae: Siphodermia   | ulula                                             | Yamaguti, 1970                                                         |
|                | Cryptogonimidae: Varialvus     | chanadrus                                        | Miller, Bray, Justine & Cribb, 2010                                   |
|                | Fellodistomatidae: Tengestia  | magna                                             | Korotaye, 1972                                                        |
|                | Hemiuridae: Ectenurus         | trachuni                                         | Yamaguti, 1934                                                         |
|                | Lepocreadiidae: Lepidapedoides | kalkali                                          | Yamaguti, 1970                                                         |
|                | Monorchidae: Allabacciger      | macrochris                                       | Hafeezullah & Siddiqi, 1970                                           |
|                | Opecoelidae: Homacreadium      | mutabile                                         | Linton, 1910                                                           |
|                |                                | Maccichia jagnanthi                              | Gupta & Singh, 1985                                                    |
|                |                                | Neolebouria blatta                              | Bray & Justine, 2009                                                  |
|                | Sclerodistomidae: Prosogonotrema | bilabiatoria                                   | Viguera, 1940                                                          |
|                | Trypanorhyncha: Laccistrorhynchus | gracilis                                      | Rudolphi, 1819                                                         |
|                |                                | Floriceps minacanthus                            | Campbell et Beveridge, 1987                                           |
|                |                                | Pseudolacistrorhynchus heroniformis             | Sakanari, 1989                                                         |
|                |                                | Otobothriidae: Otobothrium                   | mugilis Hiscock, 1954                                                 |
|                |                                | Tentaculariidae: Nybelinia goreensis            | Dollfus, 1960                                                          |
|                |                                | Tentaculariidae: Nybelinia indica               | Chandra, 1986                                                         |
**Table 2** List of 58 species identified at the species level with Latin binomial, with full authorities (Continued)

| Taxon                                      | Species Name                                      | Authority                                      |
|--------------------------------------------|---------------------------------------------------|------------------------------------------------|
| Nematoda (9)                               | Anisakidae: Raphidascaris (Ichthyascaris) etelidis | Moravec & Justine, 2012                         |
|                                            | Anisakidae: Raphidascaris (Ichthyascaris) nemipteri| Moravec & Justine, 2005                         |
|                                            | Camallanidae: Camallanus carangis Olsen, 1952     |                                                 |
|                                            | Capillariidae: Pseudocapillaria novaceledoniensis  | Moravec & Justine, 2010                         |
|                                            | Cucullanidae: Cucullanus bourdini Petter & Le Bel, | 1992                                            |
|                                            | Cucullanidae: Dichelyme etelidis Moravec & Justine,| 2011                                            |
|                                            | Philometridae: Philometra brevicollis Moravec & Justine, 2011 |
|                                            | Philometridae: Philometra mira Moravec & Justine, 2011 |
|                                            | Trichosomoidae: Huffmanela branchialis Justine, 2004 |

This Table shows all binomial names of parasite taxa collected (SLIPS); since several names are extremely long, its main purpose is to lighten the other tables and the text. Authors involved in the description and combination of taxa for Isopoda: [28,29,32,167,168]; for Copepoda: [36,37,155,169-172]; for Monopisthocotylea: [45,49,66,67,156,173-175]; for Digenea: [71-74,76,77,79,84,86,87,89,97,176-180]; for Trypanorhyncha: [99,181-188]; for Nematoda: [24,157-161,189,190].

Epinephelus tauvina, Diagramma cinerascens, Pseudolabrus sp., Trachichthodes affinis, Cromileptes altivelis, Lu. argentimaculatus, Plectropomus leopardus and Pl. maculatus [33]. It was found again later on Pl. leopardus and in addition on Pl. laevis [7]. Lu. monostigma is a new host record.

Larval isopods belonged to the Gnathiidae. Gnathiids, found as praniza larvae, were collected on 6 species of nemipterids and lutjanids (5 reef-dwelling, 1 deep water). In New Caledonia, larval gnathiids were found on most fish families examined (serranids, lethrinids, lutjanids, nemipterids and many others). Adult isopods were found on serranids and lutjanids but not on lethrinids and nemipterids [7,8]. The biodiversity of larval gnathiids is hard to evaluate [34,35], but it is likely that several species are involved.

Copepoda

Fourteen taxa, including 6 identified at the species level, were found. Seven species of Hatschekia were distinguished but only two are known species, the other five (Figure 2) are not formally described. A total of 21 undescribed Hatschekia species has now been listed from New Caledonian fish ([7,8]; this paper).

Hatschekia tanskima was originally described from Kuwait Bay, from Lu. fulviflamma [36] and is reported here from the Pacific for the first time, but from the same host. In contrast Hatschekia clava was described from Heron Island from material collected from Lu. carponotatus (Richardson) (as Lu. chrysotaenia) [37].

The copepods belonged to five families, namely Caligidae, Dissonidae, Hatschekiidae, Lernaeopodidae and Pennellidae. Larvae and premetamorphic adults belonging to the Pennellidae were found on the deep-sea lutjanid Et. coruscans. The only adult member of this family found during eight years of sampling was a single female of Lernaeolophus sultanus (Figure 3) found on Pr. filamentosus. Pennellids are known to utilise two different hosts during their life cycle, either two different fish hosts or a pelagic mollusc and a final fish host [38]. However, the life cycle of no Lernaeolophus species has ever been elucidated so it is not possible to confirm whether the developmental stages found on Pr. filamentosus are those of L. sultanus. L. sultanus exhibits the lowest host specificity of any copepod parasite, occurring on 16 different host fishes in the Mediterranean [39].

Caligus brevis is reported here from two species of Etelis, Et. carbunculus and Et. coruscans, for the first time. This species was previously reported only from labrid hosts in Japanese [40] and New Zealand waters [41]. Ho & Lin (2004) suspected that C. brevis might be synonym of Caligus ovicaps Shiino, 1952, but refrained from synonymizing them [42]. C. ovicaps has already been reported from a lethrinid host (Lethrinus haematopterus...
but it has a broad range of hosts including species of Cheirolodactylidae, Kyphosidae, Monacanthidae, Mullidae, Scaridae, and Siganidae [42].

All the copepods are from the gills; none was found on the skin. Insufficient sampling precludes interpretation of the absence of copepods from several of the fish species listed here; however, the absence of copepods on fork-tailed threadfin breams, *Ne. furcosus*, with 239 specimens examined at various seasons during eight years is certainly significant.

**Monogenea**

The minimized number of taxa for polyopisthocotyleans was 2 and for monopisthocotyleans was 23.

Polyopisthocotyleans were represented by *Allomicrocotyla* sp. on the deep-sea lutjanid *Et. coruscans*, and several records of unidentified microcotylids or other polyopisthocotylean families from coral-associated lutjanids and nemipterids. Polyopisthocotyleans on reef lutjanids were rare; similarly, polyopisthocotyleans were rare on *Lu. griseus* in the Gulf of Mexico [43]. The rarity of polyopisthocotyleans from 4 species of lutjanids off Heron Island on the Great Barrier Reef is apparent from the literature [44] and from unpublished observations by I.D. Whittington at the same locality.

Monopisthocotyleans included four families, the Ancyrocephalidae, Capsalidae, Diplectanidae and Gyrodactylidae.

Ancyrocephalids included a series of species of the recently described genus *Haliotrematoides* Kritsky, Yang & Sun, 2009, several species of Euryhaliotrema Kritsky & Boeger, 2002, which are still undescribed, and we also have records of various ancyrocephalids not attributed to a genus. Clearly, the lutjanids harbour an impressive ancyrocephalid radiation, with probably several species

**Figure 2** Undescribed new species of *Hatschekia* (Copepoda, Hatschekiidae) collected from lutjanid hosts off New Caledonia, all drawn to same scale. A, *Hatschekia* new species 21; B, *Hatschekia* new species 18; C, *Hatschekia* new species 20; D, *Hatschekia* new species 17; E, *Hatschekia* new species 19.

**Figure 3** *Lernaeolophus sultanus* (Copepoda, Pennellidae), specimen BMNH 2010.750, from *Pristipomoides filamentosus* off New Caledonia. Scale, each scale division = 1 mm.
on each fish species; some of these species seem to be strictly species-specific, others are found on up to 5 different host species [45]. These ancyrocephalids might be a threat for cultured snappers [46].

Dipllectanids included several species of Dipllectanum and one species of Calydiscoide. Calydiscoide species are numerous in lethrinids [8]; only one species was found in New Caledonia in the families studied here, in the nemipterid Pentapodus aureofasciatus, but none in members of Scolopsis and Nemipterus, which are known to harbour sometimes numerous species of Calydiscoide in other localities [44,47,48].

Four species are attributed here to Dipllectanum. D. opakapaka Yamaguti, 1968 was described from Pr. microlepis and Aphereus rutilans off Hawaii [49] and D. curvivagina Yamaguti, 1968 was described from Pr. sieboldii and Pr. auricilla off Hawaii [49] and have rarely been recorded since [50]. D. fusiformis Oliver & Paperna, 1984, described from Lu. kasmira off Kenya [51] was recorded again from its type-host and Lu. fulvus in French Polynesia and Hawaii [52,53]. D. spirale Nagibina, 1976 described from Lu. fulviflamma [54] has apparently not been recorded since its original description. In the absence of a comparative examination of the type specimens, we prefer to keep our identifications of these four species as “cf.” and we do not comment on their generic attribution.

Gyrodactylids were represented by a single specimen found on Macolor niger, which is a relatively difficult fish to catch and unfortunately additional specimens could not be obtained. It is the first gyrodactylid collected from a lutjanid. It should be noted that several coral-associated lutjanids were soaked for collection of skin monogeneans such as capsalids and digeneans such as transversotrematids, but no other gyrodactylid specimens were recovered.

Capsalid systematics is currently under reinvestigation (e.g. [55-57]) after Perkins et al. [58] demonstrated that the current morphological classification has limited congruence with a phylogenetic hypothesis based on three unlinked nuclear genes. Apparently homoplastic morphological features were highlighted throughout the molecular phylogeny [58]. This has entailed a reluctance to assign some taxa to genera until appropriate characters and generic and subfamilial definitions are better refined within a phylogenetic context. Hence ‘identifications’ of four taxa are herein provided only as Capsalidae sp. 6, 7, 13 and 17, differentiated phylogenetically by Perkins [59] using nuclear and mitochondrial markers, but from morphological ‘identifications’ made by I.D. Whittington.

Of the Capsalidae we report here, four from the gills were identified to species (Benedenia elongata from three lutjanid species; Lagenivaginapseudobenedenia etelis from Et. coruscans; Pseudonitzschia uku from Aprion virescens; Trilobiodiscus lutiani from Lu. argentinaculatus). Two capsalid species recovered from gills of Macolor niger and Ne. furcosus remained unidentified. A species assigned only as a Metabenedeniella sp. was recovered from the pectoral fins (see [59]; probably a new species, I.D. Whittington unpublished) and the four capsalid species assigned only as Capsalidae sp. 6, 7, 13 and 17 [59] were recovered from the gills, fins, body washings, branchiostegal membranes and the head of their hosts (for details, see Appendix 1). Additional external sites, rarely examined in this study, received careful scrutiny only when I.D. Whittington visited Nouméa in October/November 2008. During his visit, thorough fish necropsies (four specimens of Lu. vitta; six specimens of Ne. furcosus; one specimen of Lu. kasmira [which was totally uninfected by capsalids]; two specimens of Pr. argyrogrammicus; one specimen of Lu. argentinaculatus) paid particular attention to external microhabitats known to support capsalids (e.g. [60]) followed by freshwater bathing of the same tissues to ensure recovery of parasites that may be cryptic due to camouflage or transparency (e.g. [61]). Dissections of fish at other times, when microhabitats other than gills that may harbour capsalids remained unstudied, seem likely to have appreciably underestimated the diversity of capsalid monogeneans from the caesionids, lutjanids and nemipterids examined.

Other factors in this study that contributed to an inability to assign capsalids to genera from gills, pelvic, pectoral and anal fins, body washings, branchiostegal membranes and head included small numbers of specimens recovered and the juvenile status of many capsalid individuals from Ne. furcosus. Adult specimens of B. lutjani from Lu. carponotatus from Heron Island on the Great Barrier Reef preferentially inhabit the branchiostegal membranes, and the pelvic fins was the site where protandrous parasites that possess a vagina may become inseminated [62,63]. Discovery of juvenile specimens of Capsalidae sp. 13 on pelvic and anal fins and branchiostegal membranes and small, recently matured adults on the branchiostegal membranes of Ne. furcosus suggests a similar migration and habitat partitioning for this taxon on the nemipterid.

Several of the capsalids reported in this study represent new records. Metabenedeniella species are previously reported from oplegnathids, serranids and haemulids [64]. Our report of a Metabenedeniella sp. from a lutjanid (Appendix 1) represents a new fish family and a new geographic record for this capsalid genus. Benedenia elongata was described as Pseudobenedenia elongata from a priacanthid, Priacanthus boops, and two lutjanids, Pr. sieboldii and Arnillo auricilla (now Pr. auricilla, see [65]), off Hawaii [49]. Although two specimens of Pr. auricilla were studied in the present investigation,
B. elongata was not recorded. It has, however, been recorded from three new host lutjanid species, *Et. carbunculus*, *E. coruscans* and *Pr. argyrogrammicus*, each of which represents a new host and geographic record for *B. elongata*. Like deep water lutjanids, priacanthids can also occur in deep water and it seems as though *B. elongata* has relatively low host specificity among several deeper water fish species in these two families.

*Lagenivaginopseudobenedenia etelis* was originally described from *Et. carbunculus* off Hawaii by Yamaguti [66]. While 16 specimens of *Et. carbunculus* from New Caledonia were studied, *La. etelis* was not reported but we did record it from *Et. coruscans*, a new host and geographic record for this taxon (Appendix 1). As suggested for *B. elongata*, *La. etelis* may also exhibit relatively low host specificity and infect several deep-sea lutjanids. Further sampling may indicate whether *La. etelis* is specific to species of *Etelis* or whether this capsalid can also infect *Pristipomoides* species.

As far as we are aware, there have been no published reports of *Trilobidiscus lutiani* since its original description [67] although it does occur on the type host, *Lu. argentinamaculatus* in north Queensland (I.D. Whittington, unpublished). The present report of *T. lutiani* from New Caledonia is a new geographic record (Appendix 1).

For the same sampling limitations presented above, it is possible that specimens of Anoplodiscidae known from external surfaces of nemipterids on the Great Barrier Reef (I.D. Whittington, unpublished) may have been overlooked in the present study.

**Digenea**

The total minimized number of taxa was 33, with 21 species identified at the species level (SLIPs).

Eleven families were represented: Acanthocolpidae (2 SLIPs), Cryptogonimidae (12 spp, 9 SLIPs), Didymozoidae (2 unidentified adults, unknown number of species as unidentified larvae), Felledistomatidae (1 SLIP), Hemiuriidae (3 spp, 1 SLIP), Lecithasteridae (1 sp.), Lepocreadiidae (1 SLIP), Monorchiidae (1 SLIP), Opecoelidae (8 spp, 4 SLIPs), Sclerodistomidae (1 SLIP) and Transversotremataeidae (1 SLIP).

The dominant digenean family is the Cryptogonimidae. Members of this family and of the Acanthocolpidae and the Didymozoidae utilise fishes as second intermediate hosts [69], indicating that this component of the lutjanid (and related families) diet is a major source of its digenean fauna. The other digenean families utilise a wide range of invertebrates, often crustaceans, as second intermediate hosts, and occasionally lepocreadiids and opecoelids also use fishes [69]. Some hemiuroids (e.g. *Lecithochirium*) have interpolated a third intermediate host, a fish, into their life-cycle [70]. Considering the importance of fishes in the diet and infection of lutjanids it is, perhaps, surprising that we found no members of the common family Bucephalidae, which also utilise fishes as second intermediate hosts.

The cryptogonimids include one species, *Adlardia novaecaledoniae*, which is known only from New Caledonia [71]. Other identified cryptogonimids are reported more widely, from the Great Barrier Reef (GBR) (*Retrovarium manteri*), from Fiji (*R. saccatum*), from both these localities (*Siphoderina hirastrica*), from Hawaii (*Metadena rooseveltiae*), from Hawaii and China (*S. ulaula*) and from the Philippines and the GBR (*Euryakaina manilensis*) [72-76]. Two species also occur in the Indian Ocean. *Varialvus charadrus* occurs in the GBR and the Maldives and *E. marina* is reported from the GBR, the Bay of Bengal and Ningaloo Reef, Western Australia [77-79].

Both acanthocolpids are reported from *Aprion virescens*, and are known from the Western Pacific, from Hawaii to the Great Barrier Reef [74,75,80,81].

The Opecoelidae is a difficult group, with many similar species described. Of the four SLIPs one, *Hamacre- dium mutabile*, is a cosmopolitan parasite reported in many lutjanid species in the Atlantic, Indian and Pacific Oceans [82]. This is one of the few opecoelids known to utilise fishes as its second intermediate host [83]. Of the other species, *Neolebouria blatta* is reported only from New Caledonia, *N. lineatus* only from southern Western Australia, and *Macvicaria jagannathi* from the Bay of Bengal [84-88].

The Transversotremataeidae includes a single species, which could be identified at the species level. Morphologically and biologically this form agrees with the variable species *Transversotrema borboleta*, reported from chaetodontids and lutjanids (including *Lu. kasmira*) from the northern and southern GBR [89]. The species includes 3 genotypes which are not partitioned to different host families, but only genotype ‘G2’ is reported in *Lu. kasmira*.

Didymozoidae include several records of unidentified juveniles from coral and deep-sea lutjanids and nemip- terids; juvenile didymozoids are found in the intestine of most marine tropical fish [7,8,90,91] and the present records are not surprising. Adult didymozoids include a relatively abundant long filiform form found under the scales of the deep water *Et. carbunculus*.

Two of the other SLIPs are widespread in the Atlantic and Indo-West Pacific Region, i.e., *Ectenurus trachuri*, *Prosogonotrema bilabiatum* (see [92,93]). *E. trachuri* is mostly reported in carangids, but *P. bilabiatum* is a common parasite of lutjanids. Allobacciger macrorchis (also known as *Monorchideis macrorchis*) is reported mainly in the Indian Ocean, but also Japan [77,94,95]. *Lepidapedoides kalikali* is known only from Hawaii, Japan and Palau [74,96]. *Tergestia magna* is reported
from emmelichthyid fishes from the waters off southern Australia [97].

**Cestoda Bothriocephalidea and Tetraphyllidea**

For these two cestode orders, only larvae were found, and species identification is not possible.

Bothriocephalideans were represented by larvae found in four species of fishes. They were especially abundant and highly prevalent in *Ne. furcosus*. White, flattish larvae, about 1 cm in length, were found in the abdominal cavity and in almost all organs of this fish, including the intestinal lumen. Sometimes larvae were visible when the fish was caught, because they were protruding in the region around the anus, with half of their body buried in the flesh. We interpret these larvae as bothriocephalideans due to the lack of morphological characters.

Tetraphyllideans include small forms found in the intestinal lumen of various fishes, both from coral-associated and deeper water fishes. It is possible that these include lecanicephalideans. A detailed morphological examination was not performed.

**Cestoda Trypanorhyncha**

Only larvae were found. All these trypanorhyncs have their adults parasitic in sharks and are probably transmitted to their final host by predation. Seven species of larval trypanorhynch cestodes, all from coral-associated fish, were identified at the species level on the basis of the armature of their tentacles.

Trypanoselachoidans [98] included four species, found as larvae in cysts in the abdominal cavity. The otobothriid *Otobothrium mugilis* was found only once in the nemipterid *Nemipterus furcosus*. The lacistorhynchids *Callitetrarhynchus gracilis*, *Floriceps minacanthus* and *Pseudolacistorhynchus heroniensis* were found in a lutjanid and a nemipterid; in New Caledonia, *C. gracilis* has already been recorded from 4 serranids and 1 lethrinid, *F. minacanthus* from 6 serranids and 1 lethrinid, and *Ps. heroniensis* from 7 serranids and 2 lethriniids [7,8] and show low host specificity at the larval stage. *C. gracilis* has already been found in *Lu. vitta* in Indonesia and *F. minacanthus* has already been found in *Ne. furcosus* in Indonesia [99]. *Ne. furcosus* is a new host record for *C. gracilis*, *Lu. vitta* is a new host record for *Ps. heroniensis* and *Ne. furcosus* is a new geographical and new host record for *O. mugilis*.

Trypanobatoidans [98] included three species of the tentaculariid genus *Nybelinia*, found free in the intestinal lumen of the nemipterid *Ne. furcosus*. *Ny. goreensis* has already been found in *Ne. furcosus* in Indonesia [99] and in New Caledonia in 2 lethrinids [8]. *Ne. furcosus* is a new geographical and new host record for *Ny. indica* and for *Ny. queenslandensis*.

It is likely that this high rate of records in *Ne. furcosus* is simply a consequence of its higher sampling (see also nematodes). In addition, cysts were repeatedly found in small numbers in the abdominal cavity of several deep water lutjanids. Although there is no direct evidence that these represent trypanorhynch cestodes, we hypothesize that these larvae have a very long development time, perhaps related to the relatively cold deep water environment, and that the fish collected by us were too young to harbour fully developed larvae; deep water lutjanids have long life spans (30–40 years) [100].

**Nematoda**

The minimized number of taxa is 17, including 9 species identified at the species level.

Nematodes recorded belonged to eight families, the Anisakidae, Camallanidae, Capillariidae, Cucullanidae, Gnathostomatidae, Philometridae, Physalopteridae and Trichosomoididae.

The Anisakidae is represented by both larvae and adults. Larvae were encapsulated on the surface of organs or free in the lumen of the intestine; a few were occasionally identified at the genus level (*Anisakis* sp., *Hysterothylacium* sp., *Terranova* sp.), but most were identified only at the family level. Most fish species, whether coral-associated [7,8] or deep-sea, harbour these larvae, sometimes in very high numbers.

Adult anisakids included two newly described species of *Raphidascaris* (*Ichthyascaris*), one from the coral-
associated nemipterid *Ne. furcosus*, and one from the deep water lutjanid *E. coruscans*, and several additional specimens were found in other fish species and could not be identified at the species level.

Camallanids included one identified species, *Camallanus carangis*, and unidentified immature specimens.

Cucullanids were found only in deep water lutjanids, with *Cucullanus boudrini* in two species of *Pristipomoides*, and *Dichelyne etelidis* in two species of *Etelis*.

Unidentified gnathostomatids and physalopterids were occasionally found only in *Ne. furcosus* and probably illustrate the fact that this fish species was more intensively sampled than others, thus providing a number of records of parasites with low prevalence (see also trypanorhynchs).

Gonad-parasitic philometrids were found as two new species from *L. vitta*, but never in other fish species. Lutjanids and nemipterids are known as hosts of a few species of gonad-parasitic philometrids in other regions, such as the North Pacific, Indian and Atlantic Oceans [101,102].

Capillariids included a newly described species, *Pseudocapillaria novaecaledoniensis*, from a deep water lutjanid, but no other records were made.

Trichosomoidids included two species of *Huffmanella, H. branchialis* and *Huffmanela sp.* from the gills of two nemipterids. Interestingly, both species recorded in 2004, were never found again, despite intensive sampling of *Ne. furcosus*; their prevalence is probably very low, and their initial discovery in a small sample should be attributed to chance. Similarly, no *Huffmanella* species was recorded from more than 500 serranids examined [7], but a new species was described later from a serranid [103]. Tissue-dwelling trichosomoidids are characterised by two opposing features which probably balance each other out - very low prevalences and extremely high numbers (millions) of eggs in the few individual fish infected.

**Hirudinea, ‘Turbellaria’ and Acanthocephala**

Specimens of these three groups were rarely found.

Juvenile specimens of the piscicolid leech *Trachelobdella* sp. were found on the gills of a lutjanid and a nemipterid. Leeches of this genus are known from other lutjanids [104,105].

Cysts containing an unknown turbellarian were found rarely on the gills of *Ne. furcosus*; these were orange, abundant but with a very low prevalence, and were not studied in detail. Parasitic turbellarians are rarely found on coral reef fish [106,107].

An unidentified acanthocephalan was found once in the intestine of the deep water *Et. carbunculus*; this record constitutes a small addition to our very poor knowledge of the acanthocephalans of New Caledonia fish [6-8,108].

**A numerical evaluation of parasite biodiversity in lutjanids and nemipterids**

In presenting our results, we used the same methods as in previous similar papers of this series on serranids and lethrinids [7,8].

Our results (Appendices 1 and 2) include a number of parasite identifications, but the level of taxonomic identification varies greatly. Table 1 details the number of HPCs found in each fish species, and indicates how many fish specimens were examined; it was compiled by counting each parasitological record (i.e. each line in Appendix 1) as a host-parasite combination (HPC).

The number of HPCs differs from the actual number of different parasite species, for two reasons (a) a parasite species present in several hosts is counted as several HPCs; and (b) HPCs in Table 1 enumerate records which vary widely in systematic precision, and may designate, in a decreasing order of taxonomic precision:

- Species-level identified parasites (SLIPs); these have full binomial names, and we do not include ‘cf’ identifications within them.
- Species-level identified parasites which have not yet received a binomial (such as the numbered copepods Hatschekia sp. 17–23, Diplectanum ‘cf.’ species, and numbered capsalids). These represent valid, independent species but a comparison of the presence of these species in other localities or in other fish species will not be possible until the parasite species are formally identified, described and names are published.
- Parasite species identified at the generic level only, but which probably represent only a single species (examples: several digeneans).
- Parasite species identified at the generic level only, but for which we already know that they represent several species (example: several ancyrocephalid monogeneans).
- Parasite species identified at the family or higher level, for which we know that abundant biodiversity is hidden within this HPC. This includes unidentifiable larvae such as gnathiid isopods, anisakid nematodes, didymozoid digeneans and tetraphyllidean metacestodes. We estimate that these may represent a total of about 50–100 species.

Only species-level identified parasites with binomial (SLIPs) allow valid comparisons between localities and fish.

Table 1 includes all results, but some fishes were only studied superficially and their inclusion in further calculations would severely bias the results; for this reason,
Table 3 was constructed only from fish species of which at least several specimens have been studied. Table 3 also provides a comparison with the lethrinids and serranids of New Caledonia, based on previous results [7,8]; this comparison will be discussed below. Of course, we are aware that the number of fish studied is generally too low to provide truly significant results on parasite biodiversity, but at least these results allow comparison with other fish families studied using the same methods in the same area. Caesionids are not included in Table 3 because only a single species was involved.

For lutjanids (Table 3), the total number of HPCs was 131, and the number of different parasite species identified at the species level (SLIPs) was 40. For nemipterids (Table 3), the total number of HPCs was 42, and the number of SLIPs was 15. As usual, in addition, indistinguishable larval taxa probably correspond to a high number (50–100?) of different species, but cannot be differentiated on the basis of morphological studies.

Table 3 includes evaluations of these numbers as means per species of fish. The main results for all lutjanids (reef-associated and deeper sea) were that 10.92 HPCs were found per fish species, with 3.33 SLIPs (identified with binomial) per fish species. For nemipterids, the results were 14.00 HPCs and 5.00 SLIPs per fish species.

A comparison between reef-associated and deeper-water lutjanids

Our results provide an opportunity to compare parasite biodiversity in reef-associated and deep water fishes. It is widely accepted that fishes in deeper waters have a lower

| Family or group                  | HPCs | Isop | Cope | Mono | Poly | Dige | Both | Tetr | Tryp | Nema | Other | Total |
|----------------------------------|------|------|------|------|------|------|------|------|------|------|-------|-------|
| Lutjanidae, reef-associated      |      |      |      |      |      |      |      |      |      |      |       | 81    |
| (species: 8*; specimens: 105; gill: 48; abdomen: 72) | SLIPs | 0.25 | 0.75 | 3.75 | 0.25 | 3.00 | 0.25 | 0.50 | 0.25 | 1.13 | 0.00  | 10.13 |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 0.00 | 0.25 | 1.00 | 0.00 | 1.25 | 0.00 | 0.00 | 0.25 | 0.25 | 0.00  | 3.13  |
|                                   | SLIPs mean | 0.75 | 0.50 | 1.75 | 0.25 | 3.00 | 0.00 | 0.50 | 0.75 | 2.25 | 0.25  | 12.50 |
| Lutjanidae, deep-sea              |      |      |      |      |      |      |      |      |      |      |       | 131   |
| (species: 4*; specimens: 61; gill: 32; abdomen: 28) | SLIPs | 0.58 | 1.33 | 3.08 | 0.25 | 3.00 | 0.17 | 0.50 | 0.42 | 1.50 | 0.08  | 10.92 |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 0.33 | 0.33 | 0.83 | 0.00 | 1.25 | 0.00 | 0.00 | 0.17 | 0.50 | 0.00  | 3.33  |
|                                   | SLIPs mean | 0.75 | 0.50 | 1.75 | 0.00 | 3.00 | 0.00 | 0.50 | 1.00 | 0.00 | 0.00  | 3.75  |
| Lutjanidae, all                  |      |      |      |      |      |      |      |      |      |      |       | 161   |
| (species: 12*; specimens: 166; gill: 80; abdomen: 100) | SLIPs | 0.58 | 1.33 | 3.08 | 0.25 | 3.00 | 0.17 | 0.50 | 0.42 | 1.50 | 0.08  | 10.92 |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 0.33 | 0.33 | 0.83 | 0.00 | 1.25 | 0.00 | 0.00 | 0.17 | 0.50 | 0.00  | 3.33  |
|                                   | SLIPs mean | 0.75 | 0.50 | 1.75 | 0.00 | 3.00 | 0.00 | 0.50 | 1.00 | 0.00 | 0.00  | 3.75  |
| Nemipteridae                    |      |      |      |      |      |      |      |      |      |      |       | 42    |
| (species: 3*; specimens: 274; gill: 138; abdomen: 181) | SLIPs | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 1.00 | 0.33 | 1.33 | 0.67 | 3.67 | 0.33 | 0.67 | 2.00 | 3.33 | 0.67  | 14.00 |
|                                   | SLIPs mean | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00  | 5.00  |
| Lethrinidae                     |      |      |      |      |      |      |      |      |      |      |       | 337   |
| (17 species: 17; specimens: 423; gill: 227; abdomen: 334) | SLIPs | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 0.53 | 1.24 | 3.12 | 0.24 | 3.47 | 0.06 | 0.41 | 0.59 | 1.24 | 0.18  | 11.06 |
|                                   | SLIPs mean | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  |
| Serranidae                      |      |      |      |      |      |      |      |      |      |      |       | 337   |
| (28 species, specimens: 540; gill: 394; abdomen: 275) | SLIPs | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00  | 0.00  |
| Expressed as mean per fish species: |      |      |      |      |      |      |      |      |      |      |       |       |
|                                   | HPCs mean | 0.71 | 1.89 | 3.46 | 0.00 | 2.71 | 0.14 | 0.46 | 1.25 | 1.32 | 0.07  | 12.04 |
|                                   | SLIPs mean | 0.11 | 0.25 | 1.50 | 0.00 | 0.46 | 0.04 | 0.00 | 0.18 | 0.14 | 0.00  | 2.68  |

HPCs, number of host-parasite combinations; SLIPs: number of species-level identified parasites (the same parasite species found in different hosts is counted a single time; hence differences with numbers of SLIP-HPCs in Table 1). Source of data for lutjanids and nemipterids: Table 1 and Appendix 2, this paper; for lethrinids and serranids, Table 3 in [8].

*: species with only anecdotal data (see Table 1) were excluded from these calculations.
parasitic diversity than surface fishes [109-112]. However, in comparative studies, fish species from the deep-sea are generally from orders (e.g. Gadiformes, Ophidiiformes, Notacanthiformes) which are different from the orders of surface fishes (e.g. Perciformes); in contrast, our study allows us to compare fish from the same family, the Lutjanidae, from both environments. Moreover, collection areas were very close and adjacent, with deeper-water fishes collected from just off the barrier reef along the outer slope, i.e. less than one kilometre away from the barrier reef and the lagoon [19]. Recently, a molecular study demonstrated that monogeneans of groupers tend to widen specificity when they infect fish from the outer slope, in comparison to lagoon fish where they are strictly specific [23].

Table 3 shows that the number of HPCs in reef-associated lutjanids was 10.13 per fish species, compared with 12.50 (123%) in deep-water lutjanids. The number of SLIPs in reef-associated lutjanids was 3.13 per fish species, compared with 3.75 (125%) in deeper water lutjanids. These figures suggest that parasite biodiversity was higher in deeper-water fishes than in reef-associated fishes, a highly unexpected result.

However, we identify four biases which diminish the validity of this comparison:

(a) Depth bias. Estimates of parasite biodiversity in deep-sea fish [109-112] generally concern fish from deeper seas (i.e. 1000 m vs 100–250 m) and from other fish orders than those studied here.

(b) Size bias. Most deeper water fish examined, especially Etelis spp., were large fish, usually in the metre range size, while reef lutjanids were smaller, usually 10–30 cm in length [113]. It is known that parasite biodiversity increases with the size of hosts [8,114,115].

(c) Monogenean bias. Coral-associated lutjanids harbour a number of small acyrtocoelid monogeneans, of which a large proportion has not been described yet [45].

(d) Human bias. The high number of parasites identified at the species level in deeper water fish is probably related to the scientific interest they elicit in scientists. Systematicians like to describe rare parasites from rarely examined fish! No particular direction was given to participants of this study to balance their descriptive effort between reef and deeper water fish.

A comparison with lethrinids and serranids

Data on parasite biodiversity, compiled using the same methods at the same location, are available for two other families [7,8].

Table 4 compares parasite biodiversity in four families of reef-associated fishes, the lutjanids and nemipterids (present study), and the serranids and lethrinids [7,8]. Table 4 also compares results for data compiled from fishes with variable sample size (anecdotal collections excluded) and for fishes with significant sampling (i.e. >25 individuals). For the latter, the numbers of HPCs for lutjanids and nemipterids per fish species are 20.00 and

Table 4 Parasite biodiversity in reef-associated families: lutjanids and nemipterids compared with lethrinids and serranids, and a calculation on all four families

| Family or group | All data | Well-sampled | All data | Well-sampled |
|-----------------|----------|--------------|----------|--------------|
| Lutjanidae, reef-associated | HPCs 81 | 20 | HPCs mean 10.13 | 20.00 |
| (All data: 8 species*; well-sampled: 1 species**) | SLIPS 25 | 9 | SLIPS mean 3.13 | 9.00 |
| Nemipteridae | HPCs 42 | 25 | HPCs mean 14.00 | 25.00 |
| (All data: 3 species*; well-sampled: 1 species**) | SLIPS 15 | 13 | SLIPS mean 5.00 | 13.00 |
| Lethrinidae | HPCs 188 | 89 | HPCs mean 11.06 | 22.25 |
| (All data: 17 species; well-sampled: 4 species) | SLIPS 42 | 38 | SLIPS mean 2.47 | 9.50 |
| Serranidae | HPCs 337 | 136 | HPCs mean 12.04 | 19.43 |
| (All data: 28 species; well-sampled: 7 species) | SLIPS 75 | 74 | SLIPS mean 2.68 | 10.57 |
| Four families of reef-associated fish | HPCs 648 | 270 | HPCs mean 11.57 | 20.77 |
| (All data: 56 species; well-sampled: 13 species***) | SLIPS 148 | 125 | SLIPS mean 2.64 | 9.62 |

*: species with only anecdotal data (see Table 1) were excluded from these calculations.

**: species sampled over 30: Lutjanus vitta (n = 42); Nemipterus furcosus (n = 239).

***: SLIPS for all four families are not a simple addition of SLIPS for each families, because a few taxa are shared. These include only the digenean Stephanostomum japonocasum (shared by 2 fish families), and the four trypanorhynchs C. gracilis (shared by 4 families), F. minacanthus, Ps. heroniensis and Ny. goreensis (shared by 2–3 families).
The word coextinction was coined by Stork and Lyal (1993) [125] to express that as a host species becomes extinct, so does one or more species of parasites, and was redefined by Koh et al. (2004) [126] in a slightly broader sense as “the loss of a species (the affiliate) upon the loss of another (the host)

Knowing that parasite species are more numerous than non-parasitic species [127,128], it follows that coextinctions are more numerous than extinctions [129]. Dobson et al. (2008) [130] estimated that 3–5% of helminths are threatened by extinction in the next 50–100 years. However, Dunn (2009) [129] mentioned that there is no well documented case of the coextinction of a vertebrate parasite. Rózsa (1992) [131] pointed out that even a decrease in numbers within a host population, without the danger of extinction, could jeopardize the survival of certain parasite species. Koh et al. (2004) [126] calculated a risk of extinction of 593 species of monogeneans associated with 746 endangered species of fish. Justine (2007) [132] remarked that such a prediction underestimated the number of parasites in fish in rich ecosystems such as coral reefs. For Moir et al (2010) [133], this discrepancy highlights how biogeographic variation and knowledge gaps in dependant species biodiversity may lead to biased estimates of co-extinction risk.

Should we be concerned by the extinction of parasites? This is hard to defend to the general public, because “parasites tend to lack charisma” [129] and many blood-sucking parasites transmit diseases [134]. However, parasites play a major role in the balance of populations and the evolution of their hosts [114,129,130,135], and, as such, are an important and irreplaceable part of biodiversity and ecosystems.

The numerical evaluation of parasitic biodiversity in coral reef fish provided in the present study allows a more precise prediction of the risk of coextinction if a coral reef fish species becomes extinct, or simply has its population decreased [133]. Coral reefs are threatened across the planet [136-140] and special threats exist in New Caledonia [141,142]. Our results suggest that extinction of a coral reef fish species of average size would eventually result in the co-extinction of at least ten species of parasites.

Conclusions
As surprising as it might seem for studies mainly based on lists of parasites and morphological identifications, the present paper and our two previous similar papers [7,8] are pioneering works in the field of biodiversity of parasites of tropical coral reef fishes. Our main discovery of a parasitic biodiversity at least ten times higher than fish biodiversity has potential implications in the evaluation of loss of biodiversity when a coral reef fish species is threatened or becomes extinct.
Methods

Methods used in this paper are essentially the same as for the two previous papers of this series [7,8] and for brevity are not repeated here. For parasite collection, we used two methods targeting two sets of organs, designated as “gills” and “abdominal organs”. We generally used the “gut wash” method [143] but in some circumstances we used a simplified method [144]. Full details and possible methodological flaws were discussed previously [7,8]. In addition, we soaked a few fish in saline in order to collect surface monogeneans. A high number (239) of fork-tailed threadfin breams, Nemipterus furcosus, were examined, including specimens examined for research and specimens examined by students during practical courses at the University of New Caledonia.

Parasite specimens, generally collected by J.-L. Justine and his team, and sometimes by visiting colleagues, were forwarded to respective specialists: I. Beveridge (trypanorhynch cestodes), G. A. Boxshall (copepods), R. A. Bray and T. L. Miller (digeneans), F. Moravec (nematodes), J.-P. Trilles (isopods), I. D. Whittington (capsalid monogeneans), and J.-L. Justine (other monogeneans). Hirudineans were examined by E. Burreson (College of William and Mary, Gloucester Point, Virginia, USA); a few monogeneans were examined by L. Euzet (Sète, France); some anisakids were identified at the generic level by S. Shamsi (Charles Sturt University, Wagga Wagga, NSW, Australia). Gills of several lutjanids, prepared with hot water and formalin, were examined by D. C. Kritsky (Idaho State University, Pocatello, Idaho, USA) and monogeneans were described [45]. Sometimes external isopods were brought by fishermen and provided “anecdotal” collections.

The names of cestode orders and suborders follow Khalil et al. [145] updated by recent work [98,146,147]. Polypisthocotylean and monopisthocotylean monogeneans are treated as two independent groups, because monophyly of the monogeneans is not established [148-152]. However, since polypisthocotyleans were rare, results for both groups were often pooled. Monogeneans sometimes included in the Dactylogyridae are here considered as members of the Ancyrocephalidae [153,154]. Many specimens have been deposited in recognized collections (Appendix 3); other specimens under study are still in the collections of the various authors but will be eventually deposited in the collection of the Muséum National d’Histoire Naturelle, Paris, France (MNHN) and/or in other recognized, curated collections.

Research carried out on animals (fish) was performed in accordance with the ethical requirements of the IRD (Institut de Recherche pour le Développement, France) and University of Adelaide Animal Ethics Approval S-020-2008 for work by I.D. Whittington.

Appendix 1. Host-parasite list

New, unpublished records indicated by [0]; other records: [6,24,25,45,47,58,59,71,78,79,81,87,88,107,155-166].

8 fish species with low sample size * were included in Table 1 but not kept in final calculations of parasite numbers (Table 3).

Caesionidae

Caesio cuning (Bloch, 1791)

Dige: Hemi: Lecithochirium sp. (digestive tract) [0]
Dige: Leci: Aponurus sp. (digestive tract) [0]
Both: Unid: unidentified larvae (digestive tract) [0]
Tetr: Unid: unidentified larvae (digestive tract) [0]
Nema: Cucu: Cucullanus sp. (digestive tract) [0]

 Remarks: 8 specimens examined (4 for gills, 8 for abdominal organs)
HPCs: 5; SLIP-HPCs: 0.

Lutjanidae, reef-associated

Aprion virescens Valenciennes, 1830

Mono: Caps: Pseudonitzschia uku (gills) [58]
Dige: Acan: Pleorchis uku, immature (intestine) [81]
Dige: Acan: Stephanostomum uku (intestine) [81]

Remarks: 3 specimens examined (3 for gills, 3 for abdominal organs)
HPCs: 3; SLIP-HPCs: 3.

Lutjanus adetii (Castelnau, 1873)

Dige: Opec: Hamacreadium mutabile (digestive tract) [0]
Dige: Scle: Prosogonotrema bilabiatum immature (digestive tract) [0] (NGR)
Both: Unid: unidentified larvae (digestive tract) [0]
Nema: Anis: unidentified larvae (abdominal cavity) [0]

Remarks: 5 specimens examined (0 for gills, 5 for abdominal organs)
HPCs: 4; SLIP-HPCs: 2.

Lutjanus argentimaculatus (Forsskål, 1775)

Isop: Gnat: Praniza larvae (gills) [0]
Cope: Hats: Hatschekia n. sp. 20 (gills) [0]
Cope: Lerp: Parabrachiella lutiani (gills) [0] (NHR)
Mono: Ancy: Euryhalitrematoides sp. (gills) [45]
Mono: Ancy: Haliotrematoides novaealedoniae (gills) [45]
Mono: Ancy: Haliotrematoides potens (gills) [45]
Mono: Caps: Metabenedeniella sp. (pectoral fins) [59]
Lutjanus fulviflamma (Forsskål, 1775)

Cope: Cali: Chalimus larvae (gills) [0]
Cope: Hats: Hatcheskia tanyosoma (gills) [0] (NGR)
Mono: Ancy: Euryhaliotrema sp.(gills) [45]
Mono: Ancy: Haliotrematoides patellacirrus (gills) [45]
Mono: Ancy: Haliotrematoides tainophallus (gills) [45]
Poly: Unid (gills) [0]
Dige: Cryp: Euryakaina marina (intestine) [78]
Dige: Opec: Hamacreadium mutabile (digestive tract) [0]
Nema: Unid: unidentified larvae (abdominal cavity) [0]

Remarks: 17 specimens examined (11 for gills, 11 for abdominal organs)
HPCs: 9; SLIP-HPCs: 5.

Lutjanus fulvus (Forster, 1801) *

Mono: Ancy: Euryhaliotrema sp. (gills) [45]
Mono: Ancy: Haliotrematoides longitubocirrus (gills) [45]
Mono: Ancy: Haliotrematoides patellacirrus (gills) [45]
Mono: Ancy: unidentified (gills) [45]

Remarks: 2 specimens examined (1 for gills, 0 for abdominal organs, additional gills examined by D. C. Kritsky). * Fish species not kept for final parasite counts (Table 3) because of low sample size.
HPCs: 4; SLIP-HPCs: 2.

Lutjanus gibbus (Forsskål, 1775) *

Cope: Hats Hatcheskia clava (gills) [0] (NHR)
Mono: Ancy: unidentified (gills) [0]

Remarks: 2 specimens examined (2 for gills, 1 for abdominal organs). * Fish species not kept for final parasite counts (Table 3) because of low sample size.
HPCs: 2; SLIP-HPCs: 1.
### Lutjanus rivulatus (Cuvier, 1828)*

| Mono: Ancy | unidentified sp. (gills) [0] |
| Nema: Anis | unidentified larvae (abdominal cavity) [0] |
| Hiru: Pisc | Trachelobdella sp. immature (gills) [0] |

Remarks: 2 specimens examined (2 for gills, 2 for abdominal organs; including 1 juvenile). * Fish species not kept for final parasite counts (Table 3) because of low sample size.

HPCs: 3; SLIP-HPCs: 0.

### Lutjanus russelli (Bleeker, 1849)

| Isop: Gnat | Praniza larvae (gills) [0] |
| Mono: Ancy | Euryhaliostrongylus sp. (gills) [45] |
| Mono: Ancy | Haliotrema sp. patellacirrus (gills) [45] |
| Mono: Ancy | Haliotrema sp. longitubocirrus (gills) [45] |
| Mono: Caps | Capsalidae sp. 6 (body washing) [59] |
| Poly: Unid | unidentified immature (gills) [0] |
| Dige: Didy | unidentified larvae (intestine) [0] |
| Dige: Opec | Hamacreadium mutabile (intestine) [0] |

Remarks: 6 specimens examined (0 for gills, 1 for abdominal organs, additional gills examined by D. C. Kritsky)

HPCs: 8; SLIP-HPCs: 3.

### Lutjanus vitta (Quoy & Gaimard, 1824)

| Cope: Cali | chalimus larvae (gills) [0] |
| Mono: Ancy | Euryhaliostrongylus sp. (gills) [45] |
| Mono: Ancy | Haliotrema sp. longitubocirrus (gills) [45] |
| Mono: Ancy | Haliotrema sp. patellacirrus (gills) [45] |
| Mono: Ancy | unidentified (gills) [45] |
| Mono: Caps | Capsalidae sp. 7 (branchiostegal membranes) [59] |
| Mono: Dipl | Diplectanum cf. fusiforme (gills) [0] |
| Dige: Crys | Euryakaina maniliensis (intestine) [78] |
| Dige: Crys | Variulus charadrus (intestine) [79] |
| Dige: Didy | unidentified larvae (intestine) [0] |
| Dige: Hemi | Lecithochirium sp. (intestine) [0] |
| Dige: Opec | Hamacreadium mutabile (intestine) [0] |
| Tetr: Unid | unidentified (intestine) [0] |
| Tryp: Laci | Callitetrarhynchus gracilis (abdominal cavity) [0] |
| Tryp: Laci | Pseudolacistorhynchus heroniensis (abdominal cavity) [0] |
| Nema: Anis | Raphidascaris (Ichthyascaris) sp. (intestine) [161] |

Remarks: 42 specimens examined (19 for gills, 31 for abdominal organs, 5 unproductive soaked bodies, additional gills examined by D. C. Kritsky)

HPCs: 20; SLIP-HPCs: 9.

### Macolor niger (Forsskål, 1775)*

| Cope: Cali | Caligus n. sp. 2 (gills) [0] |
| Cope: Diss | Dissonus excavatus (gills) [155] |
| Cope: Hats | Hatschekia n. sp. 18 (gills) [0] |
| Mono: Caps | unidentified (gills) [0] |
| Mono: Gyro | unidentified (gills) [0] |
| Dige: Hemi | Lecithochirium sp. (intestine) [0] |

Remarks: 2 specimens examined (2 for gills, 1 for abdominal organs). * Fish species not kept for final parasite counts (Table 3) because of low sample size.

HPCs: 6; SLIP-HPCs: 1.

### Lutjanidae, deep water

### Etelis carbunculus Cuvier, 1828

| Isop: Cymo | Anilocra gigantea (body) [0] |
| Cope: Cali | Caligus brevis (body) [0] (NHR) |
| Cope: Cali | chalimus larvae (gills) [0] |
| Cope: Hats | Hatschekia n. sp. 21 (gills) [0] |
| Cope: Lerp | Parabrachiella sp. 2 (body) [0] |
| Mono: Caps | Benedenia elongata (gills) [0] (NHR) |
| Dige: Crys | Siphoderina ulaula (digestive tract) [0] (NHR) |
| Dige: Didy | unidentified adults (under scales) [0] |
| Dige: Opec | Neolebouria blatta (digestive tract) [87] |
| Tetr: Unid | unidentified larvae (digestive tract) [0] |
| Tryp: Unid | unidentified larvae, sterile cysts (abdominal cavity) [0] |
| Nema: Anis | Raphidascaris (Ichthyascaris) sp. (digestive tract) [0] |
| Acan: Unid | Dichelyne etelidis (digestive tract) [159] |

Remarks: 16 specimens examined (5 for gills, 3 for abdominal organs, occasional collect of skin isopods or didymozoids)

HPCs: 14; SLIP-HPCs: 6.
**Etelis coruscans** Valenciennes, 1862

Isop: Cymo: *Anilocra gigantea* (body) [0] (NHR)
Cope: Cali: *Caligus brevis* (body) [0] (NHR)
Cope: Cali: chalimus larvae (body) [0]
Cope: Penn: chalimus larvae and premetamorphic adults (body) [0]
Cope: Hats: *Hatschekia* n. sp. 21 (gills) [0]
Mono: Caps: *Benedenia elongata* (gills) [0] (NHR)
(MGR)
Mono: Caps: *Lagenivaginopseudobenedenia etelis* (gills) [0] (NHR)(NGR)
Poly: Micr: *Allomicrotyla* sp. (gills) Euzet det.
Dige: Cryp: *Siphodera* cf. onaga (digestive tract) [0]
Dige: Cryp: *Siphodera* n. sp. (digestive tract) [0]
Dige: Fell: *Tergestia magna* (digestive tract) [0] (NGR)
(NHR)
Tryp: Unid: unidentified larvae, sterile cysts (abdominal cavity) [0]
Nema: Anis: *Raphidascaris* *(Ichthyascaris) etelidis* (digestive tract) [161]
Nema: Cucu: *Dickelyne etelidis* (digestive tract) [159]

Remarks: 18 specimens examined (11 for gills, 5 for abdominal organs, occasional collect of skin isopods or didymozoids); The taxon listed as *Lagenivaginopseudobenedenia* sp. and sequenced in [59] is actually likely to be *Benedenia elongata* (I.D. Whittington, unpublished)
HPCs: 13; SLIP-HPCs: 6.

**Pristipomoides auricilla** (Jordan, Evermann & Tanaka, 1927)

Isop: Gnat: *Praniza* larvae (gills) [0]
Mono: Dipl: *Diplectanum* cf. *opakapaka* (gills) [0]
Dige: Lepo: *Lepidapedoides kalikali* (stomach) [0] (NGR)
Tetr: Unid: unidentified larva (digestive tract) [0]
Tryp: Unid: unidentified larva, sterile cysts (abdominal cavity) [0]
Nema: Anis: unidentified larvae (abdominal cavity) [0]
Nema: Cama: unidentified adults (digestive tract) [0]
Nema: Cucu: *Cucullanus bourdini* (digestive tract) [159]

Remarks: 2 specimens examined (2 for gills, 2 for abdominal organs)
HPCs: 8; SLIP-HPCs: 2.

**Pristipomoides filamentosus** (Valenciennes, 1830) *

Isop: Aegi: *Aega musorstom* (body) [0] (NHR)
Isop: Cymo: *Anilocra gigantea* (body) [0] (NHR)
Cope: Penn: *Lernaeolophus sultanus* (body) [0] (NHR)
Mono: Dipl: *Diplectanum* sp. (gills) [0]
Dige: Didy: unidentified adults (digestive tract) [0]
Dige: Didy: unidentified larvae (digestive tract) [0]
Nema: Anis: *Raphidascaris* *(Ichthyascaris) etelidis* (digestive tract) [161]
Nema: Cama: *Camallanus* sp. (digestive tract) [0]
Nema: Cucu: *Cucullanus bourdini* (digestive tract) [159]

Remarks: 7 specimens examined (2 for gills, 2 for abdominal organs, occasional collect of external isopods or copepods). * Fish species not kept for final parasite counts (Table 3) because of low sample size.
HPCs: 9; SLIP-HPCs: 5.

**Nemipteridae**

**Nemipterus furcosus** (Valenciennes, 1830)

Isop: Gnat: *Praniza* larvae (gills) [0]
Mono: Caps: unidentified (gills) (“*Benedenia* sp.” [156])
Mono: Caps: *Capsalidae* sp. 13 (pelvic and anal fins, gills, branchiostegal membranes) [0] (branchiostegal membranes) [59]
Poly: Micr: unidentified immature (gills) [156]
Dige: Cryp: *Adlardia novaezalandiae* (intestine) [71,164]
Pentapodus naganakformis (Tanaka, 1915) *

Dige: Hemi: Lecithochirium sp. (digestive tract) [0]
Dige: Opec: Macvicaria sp. (digestive tract) [0]
Tetr: Unid: unidentified larvae (intestine) [0]
Nema: Anis: unidentified larvae (abdominal cavity) [0]

Remarks: 2 specimens examined (2 for gills, 2 for abdominal organs). * Fish species not kept for final parasite counts (Table 3) because of low sample size.
HPCs: 4; SLIP-HPCs: 0.

Scolopsis bilineata (Bloch, 1793)

Nema: Anis: unidentified larvae (abdominal cavity) [0]

Remarks: 12 specimens examined (8 for gills, 9 for abdominal organs)
HPCs: 5; SLIP-HPCs: 1.

Scolopsis taenioptera (Cuvier, 1830) *

Nema: Anis: unidentified larvae (abdominal cavity) [0]

Remarks: 3 specimens examined (2 for gills, 3 for abdominal organs). * Fish species not kept for final parasite counts (Table 3) because of low sample size.
HPCs: 1; SLIP-HPCs: 0.

Appendix 2. Parasite-host list
8 fish species with low sample size * were included in Table 1 but not kept in final calculations of parasite numbers (Table 3).

Isopoda

Minimized number of taxa: 5
Number of SLIPs: total 4; Lutjanidae: reef: 1-0*, deep-sea: 3-3*, all: 4-3*; Nemipteridae: 0.
Number of non-SLIP taxa: 0
Undistinguishable larval taxa: 1 (gnathiids)

Aegi: Aega musorstom
Pristipomoides filamentosus (NHR)
Cora: Argathona macronema
Lutjanus monostigma * (NHR)
Cymo: Anilocra gigantea
Etelis carunculus
Etelis coruscans (NHR)
Pristipomoides filamentosus (NHR)
Cymo: Anilocra longicauda
  Pristipomoides argyrogrammicus (NHR)(NGR)
Gnat: Praniza larvae
  Lutjanus argentimaculatus
  Lutjanus russellii
  Nemipterus furcosus
  Pentapodus aureofasciatus
  Pristipomoides auricilla *
  Scolopsis bilineata

Copepoda

Minimized number of taxa: 14
Number of SLIPs: total 6; Lutjanidae: reef: 4-2*; deep-sea: 2-2*, all: 6-4*; Nemipteridae: 0-0*.
Undistinguishable larval taxa: 2
Note: for minimizing number of taxa, we considered that the caligid and pennellid larvae could correspond to their adult counterparts found on same or similar fish.

Cali: Caligus brevis
  Etelis carbunculus (NHR)
  Etelis coruscans (NHR)
Cali: Caligus n. sp. 2
  Macolor niger *
Cali: chalimus larvae
  Etelis carbunculus
  Etelis coruscans
  Lutjanus fulviflamma
  Lutjanus vitta
Diss: Dissonus excavatus
  Macolor niger *
Hats: Hatschekia clava
  Lutjanus gibbus *(NHR)
Hats: Hatschekia n. sp. 17
  Pentapodus aureofasciatus
Hats: Hatschekia n. sp. 18
  Macolor niger *
Hats: Hatschekia n. sp. 19
  Lutjanus kasmira
Hats: Hatschekia n. sp. 20
  Lutjanus argentimaculatus
Hats: Hatschekia n. sp. 21
  Etelis carbunculus
  Etelis coruscans
Hats: Hatschekia tanysoma
  Lutjanus fulviflamma (NGR)
Lerp: Clavellotis sp.
  Pristipomoides argyrogrammicus
Lerp: Parabrachiella lutiani
  Lutjanus argentimaculatus (NHR)
Lerp: Parabrachiella sp. 2
  Etelis carbunculus

Penn: chalimus larvae and premetamorphic adults
  Etelis coruscans
  Penn: Lernaeolophus sultanus
  Pristipomoides filamentosus (NHR)

Monopisthocotylea

Minimized number of taxa: 23
Number of SLIPs: total 11; Lutjanidae: reef: 8-8*, deep-sea: 2-2*, all: 10-10*; Nemipteridae: 1-1*.
Number of non-SLIP taxa: 10
Undistinguishable larval taxa: 0
Note: Note: for minimizing number of taxa, Euryhalitrematoides spp. and Ancyrocephalids Gen. spp. were each counted as one species (but this is certainly an underestimate), and the two unidentified capsalids and Diplectanum sp. were not counted (because they could, respectively, correspond to their better identified counterparts).

Ancy: Euryhalitrematoides lanx
  Lutjanus argentimaculatus
  Lutjanus fulviflamma
  Lutjanus fulvus *
  Lutjanus quinquelineatus
  Lutjanus russellii
  Lutjanus vitta
Ancy: Haliotrematoides longitubocirrus
  Lutjanus argentimaculatus
  Lutjanus quinquelineatus
Ancy: Haliotrematoides novaecaledoniae
  Lutjanus argentimaculatus
Ancy: Haliotrematoides patellacirrus
  Lutjanus fulviflamma
  Lutjanus fulvus *
  Lutjanus quinquelineatus
  Lutjanus russellii
  Lutjanus vitta
Ancy: Haliotrematoides potens
  Lutjanus argentimaculatus
Ancy: Haliotrematoides tainophallus
  Lutjanus fulviflamma
Ancy: unidentified sp. (often several sp.)
  Lutjanus fulvus *
  Lutjanus gibbus *
  Lutjanus kasmira
  Lutjanus quinquelineatus
  Lutjanus vitta
  Pentapodus aureofasciatus
Caps: **Benedenia elongata**
**Etelis carbunculus** (NHR)(NGR)
**Etelis coruscans** (NHR)(NGR)
**Pristipomoides argyrogrammicus** (NHR)(NGR)
Caps: **Capsalidae sp. 6**
**Lutjanus russellii**
Caps: **Capsalidae sp. 7**
**Lutjanus vitta**
Caps: **Capsalidae sp. 13**
**Nemipterus furcosus**
Caps: **Capsalidae sp. 17**
**Pristipomoides argyrogrammicus**
Caps: **Lagenivaginopseudobenedenia etelis**
**Etelis coruscans** (NHR)(NGR)
Caps: **Capsalidae sp. 13**
**Metabenedeniella** sp.
Caps: **Lagenivaginopseudobenedenia etelis**
**Pseudonitzchia uku**
Caps: **Lagenivaginopseudobenedenia etelis**
**Trilobiodiscus lutiani**
**Lutjanus argentimaculatus** (NGR)
Caps: unidentified species
**Macolor niger** *
**Nemipterus furcosus**
Dipl: **Calydiscoides limae**
**Pentapodus aureofasciatus**
Dipl: **Diplectanum cf. curvivagina**
**Pristipomoides argyrogrammicus**
Dipl: **Diplectanum cf. fusiforme**
**Lutjanus kasmira**
**Lutjanus vitta**
Dipl: **Diplectanum cf. opakapaka**
**Pristipomoides auricilla** *
Dipl: **Diplectanum cf. spirale**
**Lutjanus kasmira**
Dipl: **Diplectanum sp.**
**Pristipomoides filamentosus**
Gyro: unidentified species
**Macolor niger** *

**Polyopisthocotylea**

Minimized number of taxa: 2
Number of SLIPs: 0
Number of non-SLIP taxa: 1
Undistinguishable larval taxa: 0
Note: for minimizing number of taxa, we considered all unidentified records as a single species.

Micr: **Allomicrocotyla** sp.
**Etelis coruscans**
Micr: unidentified species
**Nemipterus furcosus**
**Pentapodus aureofasciatus**
unidentified family: unidentified species

**Lutjanus fulviflamma**
**Lutjanus russellii**

**Digenea**

Minimized number of taxa: 33
Number of SLIPs: total 20; Lutjanidae: reef: 10-10*, deep-sea: 5-4*, all 15-14*; Nemipteridae: 5-5*.
Number of non-SLIP taxa: 2
Undistinguishable larval taxa: 1 (didymozoid juveniles)
Note: for minimizing number of taxa, we considered that the single non-SLIP taxon was **Siphoderina** cf. *onaga*; the 2 **Siphoderina** sp. from deep-sea and coral lutjanids were counted as 2 taxa; unidentified adult didymozoids and unidentified juveniles were counted each as 1 taxon.

Acan: **Pleorchis uku**
**Aprion virescens**
Acan: **Stephanostomum uku**
**Aprion virescens**
Cryp: **Adlardia novaecaledonidae**
**Nemipterus furcosus**
Cryp: **Euryakaina manilensis**
**Lutjanus vitta**
Cryp: **Euryakaina marina**
**Lutjanus fulviflamma**
Cryp: **Metadena rooseveltiae**
**Pristipomoides argyrogrammicus** (NHR)(NGR)
Cryp: **Retrovarium manteri**
**Lutjanus argentimaculatus** (NGR)
Cryp: **Retrovarium saccatum**
**Lutjanus argentimaculatus** (NHR)
Cryp: **Siphoderina cf. onaga**
**Etelis coruscans**
Cryp: **Siphoderina hiarstricta**
**Lutjanus argentimaculatus**
Cryp: **Siphoderina n. sp.**
**Etelis coruscans**
**Pristipomoides argyrogrammicus**
Cryp: **Siphoderina sp.**
**Lutjanus kasmira**
Cryp: **Siphoderina ulaula**
**Etelis carbunculus** (NGR)
**Pristipomoides argyrogrammicus** (NHR)(NGR)
Cryp: **Varialvus charadrus**
**Lutjanus quinquelineatus**
**Lutjanus vitta**
Didy: unidentified adults
**Etelis carbunculus**
**Pristipomoides filamentosus**
Didy: unidentified juveniles
**Lutjanus kasmira**
**Lutjanus russellii**
**Lutjanus vitta**
Nemipterus furcosus
Pristipomoides filamentosus
Fell: Tergestia magna
Etelis coruscans (NHR)(NGR)
Hemi: Ectenurus trachuri
Nemipterus furcosus (NHR)(NGR)
Hemi: Lectichocirium sp.
Caesio cuning
Lutjanus kasmira
Lutjanus vitta
Macolor niger *
Pentapodus nagasakienensis *
Pentapodus aureofasciatus
Hemi: Lecthoeladium sp.
Pentapodus aureofasciatus
Leci: Aponurus sp.
Caesio cuning
Lepo: Lepidapedoides kalikali
Pristipomoides auricilla * (NGR)
Monr: Allobacciger macrorchis
Scolopsis bilineata
Hemi: Allopodocotyle sp.
Scolopsis bilineata
Opec: Hamacreadium mutabile
Lutjanus adetii
Lutjanus argentimaculatus (NHR)
Lutjanus fulviflamma
Lutjanus kasmira
Lutjanus quinquelineatus
Lutjanus russelli
Lutjanus vitta (NHR)
Opec: Macvicaria jagannathi
Nemipterus furcosus
Opec: Macvicaria sp.
Pentapodus nagasakienensis *
Opec: Neochoanostoma sp.
Pentapodus aureofasciatus
Opec: Neolebouria blatta
Etelis carbunculus
Pristipomoides argyrogrammicus
Opec: Neolebouria lineatus
Nemipterus furcosus
Opec: Neolebouria sp.
Pentapodus aureofasciatus
Scle: Prosogonotrema bilabiatum
Lutjanus adetii (NGR)
Tran: Transversotrema borboleta
Lutjanus kasmira (NGR)

Bothriocephalidea

Minimized number of taxa: 1
Number of SLIPs: 0

Nemipterus furcosus

Number of non-SLIP taxa: 0
Undistinguishable larval taxa: 1

unidentified family: unidentified species, larvae
Caesio cuning
Lutjanus adetii
Lutjanus kasmira
Nemipterus furcosus

Tetraphyllidea

Minimized number of taxa: 1
Number of SLIPs: 0
Number of non-SLIP taxa: 0
Undistinguishable larval taxa: 1

unidentified family: unidentified species, larvae
Caesio cuning
Etelis carbunculus
Lutjanus argentimaculatus
Lutjanus kasmira
Lutjanus quinquelineatus
Lutjanus vitta
Nemipterus furcosus
Pentapodus aureofasciatus
Pentapodus nagasakienensis *
Pristipomoides argyrogrammicus
Pristipomoides auricilla *

Trypanorhyncha

Minimized number of taxa: 8
Number of SLIPs: 7
Number of SLIPs: total 7; Lutjanidae: reef: 2-2*, deep-sea: 0-0*, all 2-2*; Nemipteridae: 6-6*.
Number of non-SLIP taxa: 0
Undistinguishable larval taxa: 1
Note: for minimizing number of taxa, we considered that all unproductive cysts from deep-sea lutjanids corresponded to 1 taxon and was distinct from the four other cyst-producing species.

Laci: Callitetrarhynchus gracilis, larvae
Lutjanus vitta
Nemipterus furcosus (NHR)
Laci: Floriceps minacanthus, larvae
Nemipterus furcosus
Laci: Pseudolacistorhynchus heroniensis, larvae
Lutjanus vitta (NGR)
Otab: Otobothrium mugilis, larvae
Nemipterus furcosus (NHR)(NGR)
Tent: Nybelinia goreensis, larvae
Nemipterus furcosus
Tentaculariidae: *Nybelinia indica*, larvae
*Nemipterus furcosus* (NHR)(NGR)

Tentaculariidae: *Nybelinia queenslandensis*, larvae
*Nemipterus furcosus* (NHR)(NGR)

unidentified family: unidentified species, larvae
*Etelis carbunculus*
*Etelis coruscans*
*Pristipomoides argyrogrammicus*
*Pristipomoides auricilla*

Nematoda

Minimized number of taxa: 17
Number of SLIPs: total 9; Lutjanidae: reef: 2-2*, deep-sea: 4-4*, all 6-6*; Nemipteridae: 3-3*.
Number of non-SLIP taxa: 6
Undistinguishable larval taxa: 1 (anisakids, gnathostomatids)

Note: for minimizing number of taxa, we considered that unidentified anisakids corresponded to one of the 3 identified larval anisakid genera; *Camallanus* sp. and unidentified camallanids were counted as a single species; *Huffmanela* sp. was distinguished as different; the *Raphidascaris (Ichthyascaris)* sp. from reef lutjanids was different from that from deep-sea.

Anis: *Anisakis* sp., larvae
*Nemipterus furcosus*

Anis: *Hysterothylacium* sp., larvae
*Nemipterus furcosus*

Anis: *Raphidascaris (Ichthyascaris) etelidis*
*Etelis coruscans*
*Pristipomoides filamentosus*

Anis: *Raphidascaris (Ichthyascaris) nemipteri*
*Nemipterus furcosus*

Anis: *Raphidascaris (Ichthyascaris) sp.*
*Etelis carbunculus*
*Lutjanus vitta*

Anis: *Terranova* sp., larvae
*Lutjanus vitta*

Anis: unidentified species, larvae
*Lutjanus adetii*
*Lutjanus fulviflamma*
*Lutjanus kasmira*
*Lutjanus quinquelineatus*
*Lutjanus rivulatus*
*Pentapodus aureofasciatus*
*Pentapodus nagasakiensis*
*Pristipomoides argyrogrammicus*
*Pristipomoides auricilla*
*Scolopsis taenioptera*

Cama: *Camallanus carangis*
*Nemipterus furcosus*

Cama: *Camallanus sp.*
*Pristipomoides filamentosus*

Cama: unidentified species
*Lutjanus vitta*
*Pristipomoides auricilla*
*Scolopsis bilineata*

Capi: *Pseudocapillaria novaecaledoniensis*
*Pristipomoides argyrogrammicus*

Cucu: *Cucullanus bourdini*
*Pristipomoides auricilla*
*Pristipomoides filamentosus*

Gnto: unidentified species

Phil: *Philometra brevicollis*
*Lutjanus vitta*

Phil: *Philometra mira*
*Lutjanus vitta*

Phys: unidentified species

Tric: *Huffmanela branchialis*
*Nemipterus furcosus*

Tric: *Huffmanela sp.*
*Pentapodus aureofasciatus*

Hirudinea

Minimized number of taxa: 1
Number of SLIPs: 0
Number of non-SLIP taxa: 1
Undistinguishable larval taxa: 0

Pisc: *Trachelobdella* sp., juvenile
*Lutjanus rivulatus*
*Scolopsis bilineata*

Turbellaria

Minimized number of taxa: 1
Number of SLIPs: 0
Number of non-SLIP taxa: 1
Undistinguishable larval taxa: 0

unidentified family: unidentified species
*Nemipterus furcosus*

Acanthocephala

Minimized number of taxa: 1
Number of SLIPs: 0
Number of non-SLIP taxa: 1
Undistinguishable larval taxa: 0
unidentified family: unidentified species

_Etelsis carbunculus_

### Appendix 3. Material deposited

**Pisces**

_Nemipterus furcosus_, MNHN 2005–0768, 2006–1330. _Pentapodus aureofasciatus_, MNHN 2004–1168, 2004–1169, 2004–2164, 2004–2172.

**Isopoda**

_Aegi: Aega musorstrom ex Pr. filamentosus, MNHN Is6295, Is6296, Is6297, Is6298._
_Cora: Argathona macronema ex Lu. monostigma, MNHN Is6299._
_Cymo: Anilocra gigantea ex Et. carbunculus, MNHN IU-2009-1710, IU-2009-1712; ex Et. coruscans, MNHN Is6293, MNHN-IU-2009-1711; ex Pr. filamentosus, MNHN Is6292._
_Cymo: Anilocra longicauda ex Pr. argyrogrammicus, MNHN Is6294._

**Copepoda**

_Cali: Caligus brevis, ex Et. coruscans, MNHN Cp8059, BMNH 2010.767–769; ex Et. carbunculus, BMNH 2010.770–771._
_Diss: Dissonus excavatus, ex Ma. niger, MNHN Cp2436, BMNH 2007.316–325._
_Hats: Hatschekia clava, ex Lu. gibbus, MNHN Cp8067._
_Hats: Hatschekia tanyosoma, ex Lu. fulviflamma, MNHN Cp8068–8069._
_Penn: Lernaeolophus sultanus, ex Pr. filamentosus, BMNH 2010.750._
_Lerp: Parabrachiaella sultani, ex Lu. argenticulatus, MNHN Cp8060, BMNH 2010.786–791._

**Monogenea**

_Ancy: Haliotrematoides tainophilus ex Lu. argenticulatus, slides MNHN JNC2332, USNPC 101336, BMNH 2008.11.19.34–35; ex Lu. fulviflamma, slide MNHN JNC2551; ex Lu. fulvus, slides MNHN JNC1591, JNC1592, USNPC 101341, BMNH 2008.11.19.32–33; ex Lu. quinquelineatus, slides MNHN JNC2146, JNC2147, JNC2142, JNC2141, JNC2144, USNPC 101342, 101343, BMNH 2008.11.19.34–35; ex Lu. vitta, MNHN 2470._
_Ancy: Haliotrematoides potens ex Lu. argenticulatus, slides MNHN JNC2332, USNPC 101336, BMNH 2008.11.19.23._
_Ancy: Haliotrematoides tainophilus ex Lu. fulviflamma, slides MNHN JNC2531._
_Caps: Benedenia elongata ex gills Et. carbunculus (fish JNC2459) SAMA AHC 35066 (6 slides)._**Caps: Benedenia elongata ex gills Et. coruscans (fish JNC2448) MNHN JNC2448 A1 (1 slide)._**Caps: Benedenia elongata ex gills Pr. argyrogrammicus (from fish JNC2449) MNHN JNC2449 B1 (1 slide), (from fish JNC2603) MNHN JNC2603 A3 (1 slide), SAMA AHC 35067 (2 slides), (from fish JNC2604) MNHN JNC2604 A1 (1 slide), (from fish JNC2729) AHC 35068 (1 slide of a single specimen that was ‘slivered’; sliver fixed in 95% ethanol; possibly conspecific with Capsalidae sp. 17 of Perkins 2010), (from fish JNC2730) SAMA AHC 35069 (1 slide)._**Caps: Capsalidae sp. 7 (see Perkins 2010) ex branchiostegal membranes Lu. vitta (from fish JNC2686) SAMA AHC 29706 (1 slide)._**Caps: Lagenivaginopseudobenedenia etelis ex gills Et. coruscans (from fish JNC2616) MNHN JNC2616 A1 (1 slide), JN111, JN115, JN119._**Caps: Metabenedeniella sp. (see Perkins 2010) ex pectoral fins Lu. argentimaculatus (from fish JNC2735) SAMA AHC 29714 (3 slides)._**Caps: Pseudonitzschia uku (see Perkins et al. 2009) ex gills Aprion virescens (from fish JNC1557) MNHN JNC1557 A1 (1 slide), SAMA AHC 35070 (2 slides)._**Caps: Trilobiodiscus lutiani (see Perkins 2010) ex branchiostegal membranes _Ne. furcosus_ (from fish JNC2692) SAMA AHC 29707 (2 slides), AHC 35073 (4 slides)._**Caps: Capsalidae sp. 13 (see Perkins 2010) ex branchiostegal membranes _Ne. furcosus_ (from fish JNC2692) SAMA AHC 29707 (2 slides), AHC 35073 (4 slides)._**Caps: Capsalidae sp. 13 of Perkins (2010) ex gills _Ne. furcosus_ (from fish JNC971) MNHN JNC971A6 (1 slide), SAMA AHC 35071 (2 slides), (from fish JNC2692) SAMA AHC 35072 (5 slides), (from fish JNC2693) SAMA AHC 35075 (4 slides), (from fish JNC2694) SAMA AHC 35076 (6 slides), (from fish JNC2695) SAMA AHC 35077 (2 slides)._**Caps: Capsalidae sp. 13 of Perkins (2010) ex pelvic and anal fins _Ne. furcosus_ (from fish JNC2694), SAMA AHC 35074 (3 slides).
Digenea

Polyopisthocotylea

Micr: Allomicrocotyla sp. ex Et. coronavirus, slides JN114.

Unidentified polyopisthocotylean ex Lu. russellii, slide JNC1582.

Digenea

Acan: Pleorchis uku ex Aprion virescens, MNHN JNC2568.
Acan: Stephanostomum uku ex Ap. virescens, MNHN JNC1557C.

Cryp: Adlardiinae novaecaledonae ex Ne. furcatus, MNHN JNC2291–1, 16, MNHN JNC2289–1–5, MNHN JNC2291–2–4, MNHN JNC2331B–1–4, MNHN JNC2288–1–3, MNHN JNC2398–1, 10; BMNH 2008.12.30.1–3.

Cryp: Euryakaina maniilensis ex Lu. vitta, MNHN JNC2285, MNHN JNC2286, MNHN JNC2306, MNHN JNC2470, MNHN JNC2686, MNHN JNC2862, MNHN JNC2887, MNHN JNC2897, MNHN JNC2898, MNHN JNC2900, MNHN JNC2902; BMNH 2010.4.23.1–12.

Cryp: Euryakaina marina ex Lu. fulviflamma, MNHN JNC1269B.

Cryp: Retrovarium manteri ex Lu. argintimaculatus, MNHN JNC 2735–2, BMNH 2012.2.15.7

Cryp: Retrovarium saccatum ex Lu. argintimaculatus, MNHN JNC 2735–3

Cryp: Siphoderina hirastricta ex Lu. argintimaculatus, MNHN JNC 2735–1

Cryp: Varialvus charadrus ex Lu. quinquelineatus, MNHN JNC2143; ex Lu. vitta MNHN JNC2285, MNHN JNC2688, MNHN JNC2689.

Fell: Tergestia magna ex Et. coronavirus, MNHN JNC 2616B–1, JNC2617B–1; ex Pr. argyro grammicus, MNHN JNC2820B–1.

Hemi: Ecetnurus trachuri ex Ne. furcatus, MNHN JNC2586–1.

Lepo: Lepidapedoides kalikali ex Pr. auricilla, MNHN JNC2457–1, JNC2468–1, BMNH 2012.2.15.6.

Monr: Allobacciger macrorchis ex Sc. bilinea, MNHN JNC2522–1, BMNH 2012.2.15.16.

Opec: Hamaecradium mutabile ex Lu. adetii, MNHN JNC3021–1; ex Lu. argintimaculatus, MNHN JNC2735–2, BMNH 2012.2.15.15; ex Lu. fulviflamma, BMNH JNC2531–1, BMNH 2012.2.15.13; ex Lu. kasmira, MNHN JNC2708–1–2, BMNH 2012.2.15.14; ex Lu. quinquelineatus, MNHN JNC 2142–1; ex Lu. russellii, MNHN JNC2191–1; ex Lu. vitta, MNHN JNC 2285–1, MNHN JNC2306–1, MNHN JNC2470–1, MNHN JNC2686–1, MNHN JNC2900–1, MNHN JNC2896–1, MNHN JNC2898–1, MNHN JNC2899–1, BMNH 2012.2.15.9–12.

Opec: Macvicaria jagannathi ex Ne. furcatus, MNHN JNC2331A–1–3, JNC2366A–1, BMNH 2009.2.12.11–14.

Opec: Neolebouria blatta ex Et. carbunculus, MNHN JNC2427; ex Pr. argyro grammicus, MNHN JNC2464–1, MNHN JNC2426, MNHN JNC2456, MNHN JNC2461, MNHN JNC2464–66, MNHN JNC2604–05, MNHN JNC 2729, MNHN JNC2995–1, MNHN JNC2996A–1; BMNH 2009.4.7.1–7, 2012.2.15.8.

Opec: Neolebouria lineatus ex Ne. furcatus, MNHN JNC2398–1–2; BMNH 2009.12.15.

Scle: Prosogonotrema bilabiatum ex Lu. adetii, MNHN JNC3022–1.

Tran: Transversotrema borborela ex Lu. kasmira, MNHN JNC2708.

Trypanorhyncha

Laci: Callitetrarhynchus gracilis ex Ne. furcatus, slide MNHN JNC2596.

Laci: Floriceps minacanthus ex Ne. furcous, slide MNHN JNC3019.

Otoc: Otobothrium mugilis ex Ne. furcous, slides MNHN JNC2610, JNC2586.

Tent: Nybelinia goreensis ex Ne. furcous, slide MNHN JNC2612.

Tent: Nybelinia indica ex Ne. furcous, slides MNHN JNC2288, JNC2611, JNC3016.

Nematoda

Anis: Raphidascaris (Ichthyascaris) etelidis ex Et. coronavirus, MNHN JNC2616, JNC2617, JNC2623, HCIP N–969; ex Pr. filamentosus, MNHN JNC2460.

Anis: Raphidascaris (Ichthyascaris) nemipteri ex Ne. furcous, MNHN JNC218, JNC330, JNC214, JNC217, JNC278, JNC311, HCIP N–836.

Cama: Camallanus carangis ex Ne. furcous, MNHN JNC276, JNC280, JNC465, JNC467, JNC1261, HCIP N–859.

Capi: Pseudocapillaria novaecaledoniensis ex Pr. argyro grammicus, MNHN JNC2604, HCIP N–930.

Capi: Cucullanus bourdini ex Pr. auricilla MNHN JNC2457, ex Pr. filamentosus JNC2460, HCIP N–949.
Cucu: *Dichelyne etelidis* ex *Et. carbunculus*, MNHN JNC2459, HCIP N-948; *et. coruscans*, MNHN JNC2617.

Phil: *Philometra brevicollis* ex *Lu. vitta*, MNHN JNC2901, JNC2038, HCIP N-967.

Phil: *Philometra mira* ex *Lu. vitta*, MNHN JNC2901, HCIP N-968.

Tric: *Huffmanela branchialis* ex *Ne. furcospus*, MNHN JNC216, HCIP N-816, BMNH 2004.2.18.1, SAMA AHC 32856.

Tric: *Huffmanela sp. ex Pe. aureofasciatus*, MNHN JNC1040.

**Abbreviations**

NGR: New geographic record; NHR: New host record; HPC: Host-parasite combination; SLIP: Species-level identified parasite; SLIP-HPC: Species-level identified parasite – host-parasite combination.

**Institutional abbreviations**

BMNH: Natural History Museum, London, United Kingdom; HCIP: Helminthological Collection, Institute of Parasitology, Biology Centre, Academy of Sciences of the Czech Republic; České Budějovice, Czech Republic; MNHN: Muséum National d’Histoire Naturelle, Paris, France; SAMANHC: South Australian Museum Adelaide, Australian Helminthological Collection, Adelaide, Australia; USNPC: United States National Parasite Collection, Beltsville, USA.

**Abbreviations for higher parasite taxa**

The following abbreviations are used in Tables and Appendices: For all:

- Unid: Unidentified family; Isop: Isopoda; Families: Aeg: Aegea; Cora: Corallanidae; Cymo: Cymothoidae; Gnath: Gnathostomatidae; Cope: Copepoda; Families: Cali: Caligidae; Diss: Disonidae; Hats: Hatschekididae; Lepr: Lernaeopodidae; Penn: Pennellidae; Mono: Monogenea; Monop: Monopisthocotylea; Poly: Polyopisthocotylea; Families: Ancy: Ancyrocephalidae; Caps: Capsulidae; Dipl: Diplectanidae; Gyro: Gyrodactyliidae; Micr: Microcotylidae; Dige: Digenea; Families: Acan: Acanthocephalidae; Crypt: Cryptogonimidae; Didy: Didymozoidae; Feld: Fellodistomatidae; Hemi: Hemiuriidae; Leci: Lecithodidae; Lepo: Lepocreadiidae; Monr: Monorchiidae; Opec: Opecoelidae; Sder: Sclerodistemidae; Tran: Transversotrematidae; Tryp: Cestoda Trypanorhynchidae; Families: Laci: Lactostomidae; Oto: Otobothriidae; Tent: Tentaculariidae; Both: Cestoda Bothriocelphalidea (no family identified); Tetr: Cestoda Tetraphyllidea (no family identified); Nema: Nematomorpha; Families: Anis: Anisakidae; Cama: Camallanidae; Capl: Capillariaidae; Curu: Cucullanidae; Gnto: Gnathostomatidae; Phil: Philometridae; Phys: Physalopteridae; Tric: Trichosomoididae; Hiru: Hirudinea (no family identified); Family: Pisc: Piscicoleidae; Turb: Turbellaria; Acantho: Acanthocephala (no family identified).

**Competing interests**

The authors declare that they have no competing interests.

**Authors’ contributions**

JLJ collected fish and parasites and compiled and compared results. JLJ IB GAB RAB TLM FM JPT IDW identified parasites. GAB JLI made figures. JLJ IB GAB RAB TLM FM JPT IDW wrote the paper. Authors are in alphabetical order, except JLJ. All authors read and approved the final manuscript.

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**References**

1. Reaka-Kudla ML: *The global biodiversity of coral reefs: a comparison with rain forests*. In *Biodiversity & Understanding and protecting our biological resources*. Edited by Reaka-Kudla ML, Wilson DE. E.O. W. Washington: Joseph Henry Press; 1997:108–115.
2. Rohde K: Marine parasitology in Australia. *Aquatic Biosystems* 2012, 8:22.
3. Rohde K: Marine parasitology in Australia. *Aquatic Biosystems* 2012, 8:22.
4. Cribb TH, Bray RA, Barker SC, Adlard RD, Anderson GR: Ecology and diversity of digenean trematodes of reef and inshore fishes of Queensland. *Int J Parasitol* 1994, 24:851–860.
5. Whittington ID. Diversity "down under": monogeneans in the Antipodes (Australia) with a prediction of monogenean biodiversity worldwide. Int J Parasitol 1998, 28:1481–1493.

6. Justine JL. Parasites of coral reef fish: how much do we know? With a bibliography of fish parasites in New Caledonia. Belg J Zool 2010, 140:155–190. Suppl.

7. Justine JL, Beveridge I, Boxshall GA, Bray RA, Moravec F, Trilles J-P, Whittington ID: An annotated list of parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda and Nematomata) collected in groupers (Serranidae, Epinephelinae) in New Caledonia emphasizes parasite biodiversity in coral reef fish. Folia Parasitol 2010, 57:237–262.

8. Justine JL, Beveridge I, Boxshall GA, Bray RA, Moravec F, Whittington ID: An annotated list of fish parasites (Copepoda, Monogenea, Digenea, Cestoda and Nematomata) collected from Emperors and Emperor Bream (Lethrinidae) in New Caledonia further highlights parasite biodiversity estimates on coral reef fish. Zootaxa 2010, 2591:1–40.

9. Allen GR. FAO species catalogue. Vol. 8. Fusilier fishes of the world. An annotated and illustrated catalogue of caesionid species known to date. FAO Fisheries Synopsis 125. Rome: FAO; 1990.

10. Carpenter KE. FAO species catalogue. Vol. 6. Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date. FAO Fisheries Synopsis 125. Rome: FAO; 1988.

11. Russell BC. FAO Species catalogue. Vol. 12. Nemipterid fishes of the world. (Threadfin breams, whiptail breams, monocle breams, dwarf monocle breams, and coral breams). Family Nemipteridae: An annotated and illustrated catalogue of nemipterid species known to date. FAO Fisheries Synopsis 125. Rome: FAO; 1990.

12. Miller TL, Cribb Th. Phylogenetic relationships of some common Indo-Pacific snappers (Perciformes: Lutjanidae) based on mitochondrial DNA sequences, with comments on the taxonomic position of the Caesioninae. Mol Phylotemat Evol 2007, 44:450–460.

13. Gold JR, Voelker G, Renshaw MA. Phylogenetic relationships of tropical western Atlantic snappers in subfamily Lutjaninae (Lutjanidae: Perciformes) inferred from mitochondrial DNA sequences. Mar Biotechnol 2007, 9:662–668.

14. Guo Y, Wong Z, Liu C, Liu Y. Phylogenetic relationships of South China Sea snappers (Genus Lutjanus; Family Lutjanidae) based on mitochondrial DNA sequences. Mar Biotechnol 2007, 9:662–668.

15. Guo Y, Wang Z, Liu C, Liu Y. Sequencing and analysis of the complete mitochondrial DNA of Russell’s snapper (L. russelli). Progr Nat Sci 2008, 18:1233–1238.

16. Eschmeyer WN, Fong JO. Pisces. In Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. Zootaxa, Volume 3148. Edited by Zhang Z-Q. 2012,11:27–38.

17. Fricke R, Kulbicki M, Wantiez L. Checklist of the fishes of New Caledonia, and their distribution in the Southwest Pacific Ocean (Pisces). Stuttg Beitr Natk Ser A (Biol) 2011, 4:341–463.

18. Kulbicki M, Boez Y-M, Labrosse P, Mou-Tham G, Wantiez L. Diet composition of carnivorous fishes from coral reef lagoons of New Caledonia. Aquat Living Resour 2005, 18:231–250.

19. Faumanpiti Y. Pêche profonde en Nouvelle-Caledonie et aux Loyauté. Nourrit: Commission du Pacifique Sud / South Pacific Commission (CPS/SPC) 1977:8. www.spec.int.

20. Marie AD, Justine JL. Monocotylids (Monogenea: Monopisthocotylea) from Aetobatus cf. narinari off New Caledonia, with a description of Decacotyle elpora n. sp. Syst Parasitol 2005, 60:175–185.

21. Justine JL, Dupoux C, Cribb Th. Resolution of the discrepant host-specificity of Pseudohabdosynochus species (Monogenea, Diplostomidae) from serranid fishes in the tropical Indo-Pacific. Acta Parasitol 2009, 54:110–130.

22. Justine JL, Bitand MJ. Three new species, Lamelloscliodsus tubulicornis n. sp., L. magnicornis n. sp. and L. parvicornis n. sp. (Monogenea: Diplostomidae) from Gymnocranius spp. (Lethrinidae: Monotaxinae) off New Caledonia, with proposal of the new morphological group "tubulicornis" within Justine, Lamellosoridae and Genus: Lamelloscliodsus. Syst Parasitol 2010, 75:159–179.

23. Schoelink C, Cruaud C, Justine JL. Are all species of Pseudohabdosynochus strictly host specific? – a molecular study. Parasitol Int 2012, 61:356–359.

24. Justine JL. Three new species of Huffmannela Moravec, 1987 (Nematoda: Trichosomoididae) from the gills of marine fish off New Caledonia. Syst Parasitol 2004, 59:29–37.

25. Justine JL. Huffmannela spp. (Nematoda, Trichosomoididae) parasites in coral reef fishes off New Caledonia, with descriptions of H. balista n. sp. and H. longa n. sp. Zootaxa 2007, 1628:23–41.

26. Trilles J-P. Sur quatre Isopodes Cymothoidés du Pacifique (Nouvelle Caledonie). Cahiers ORSTOM, série Ocean 1972, 103–17.

27. Bruce NL, Harrison-Nelson EB. New records of fish parasitic marine isopod crustaceans (Cymothoidae, subfamily Anilocrinea) from the Indo-West Pacific. Proc Biol Soc Wash 1988, 101:585–602.

28. Herlitszka J. Deux nouveaux genres de Crustacés vivant en parasites sur des poissons, Epithypses et Ichthyoxenes. Arch Néerl Sci Nat 1870, 1:120–137.

29. SchaeDE J, Meinert FW. Symbolae ad Monographiam Cymothoarum Crustaceorum Isopodum Familiae 2. Anilocrini. Naturhistorisk Tidsskrift 1881, 13:31–166.

30. Trilles J-P. Les Cymothoïdes (Crustacea, Isopoda) du Monde (Prodomme pour une Faune). Stud Mar 1994, 21:225–288.

31. Bruce NL. Australian Pleopodidae Richardson, 1910, and Anilocra Leach, 1818 (Isopoda: Cymothoidea): crustacean parasites of marine fishes. Rec Aust Mus 1967, 39:25–130.

32. Delaney M. Phylogeny and Biogeography of the Marine Isopod Family Corallioidae (Crustacea, Isopoda, Flabilliferida). Contr Sci 1989, 409:1–75.

33. Smith NJ, Basson L. Gnothia pantherina sp. n. (Crustacea: Isopoda: Gnathiidae), a temporary ectoparasite of some elasmobranch species from southern Africa. Folia Parasitol 2000, 49:137–151.

34. Smith NJ, Basson L, Van As JG. Life cycle of the temporary fish parasite, Gnothia africana (Crustacea: Isopoda: Gnathiidae), parasitic on marine fishes of Kuwait. Syst Parasitol 2001, 49:73–79.

35. Kabata Z. Copoepoda parasitica on Australian fishes, XIII - Family Hatschiellidae. J Nat Hist 1991, 25:451–129.

36. Boxshall GA, Halsey SH. An introduction to copepod diversity. London: Ray Society; 2004.

37. Faust A, Couple C, Biont F. Analysis of the parasitic copepod species richness among Mediterranean fish. J Mar Syst 2004, 51:135–142.

38. Ho J-S, Lin C-L. Copepoda parasitic on Australian fishes, XIII - Family Hatschiellidae) parasitic on marine fishes of Kuwait. Syst Parasitol 2001, 49:73–79.

39. Shiino SM. Some New Zealand parasitic Copepoda of the Family Hatschiellidae. Syst Parasitol 1987, 19:356–358.

40. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.

41. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.

42. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.

43. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.

44. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.

45. Shiino SM. Hatschiellia new genus and descriptions of new and previously described species from marine fishes of the Red Sea, the eastern and Indo-West Pacific Ocean, Gulf of Mexico and Caribbean Sea. Zootaxa 1990, 1:51–57.
49. Yamaquti S. Monogenetic Trematodes of Hawaiian Fishes. Honolulu: University of Hawaii Press; 1968.
50. Kent ML, Heidel JR, Marie A, Moriwake A, Moriwake V, Alexander B, Watral V, Kelley CD. Diseases of Opakapaka Pripstomoides filamentosus. Fish Health Section. In Diseases in Alaskan Aquaculture. V Edited by Walker P, Lester R, Bondad-Reantaso MG. Manila, Asian Fisheries Society, 2005:183–195.
51. Oliver G, Papenma J. Diplectanidae Bychowsky, 1957 (Monogenea, Monopisthocotylea), parasitae de Perciformes de Mediterranea orientale, de la mer Rouge et de l’océan Indien. Bull Mus Natl Hist Nat, Paris 1964, 46, section A:49–65.
52. Vignon M, Morat F, Galzin R, Saad P. Evidence for spatial limitation of the bluestripe snapper Lutjanus kasmira in French Polynesia from parasite and otolith shape analysis. J Fish Biol 2008, 73:3230–3232.
53. Vignon M, Saad P, Rigby MC, Galzin R. Multiple parasite introduction and host management plan: case study of lutjanid fish in the Hawaiian Archipelago. Dis Aquat Org 2009, 85:133–145.
54. Nagibina LF: New species of the genus Diplectanum (Monogeneidea, Diplectanidae). In: FishBase. World Wide Web electronic publication.
55. Devaney MR, Whittington ID. New species of Benedenia Diesing, 1858 from the Great Barrier Reef, Australia with a key to species of the genus, Zootaxa 2010, 2348:1–22.
56. Whittington ID. Revision of Benedeniellia Johnston, 1929 (Monogenea: Capsalidae), its assignment to Entodellinae Bychowsky, 1957 and comments on subfamilial composition. Zootaxa 2010, 2519:1–30.
57. Whittington ID, Devaney MR. New Benedenia species (Monogenea: Capsalidae) from Diagramma labiosum (Percomorphae: Haemulidae) on the Great Barrier Reef, Australia, with oncomiracidial descriptions and a report of egg attachment to the host. J Parasitol 2011, 97:1026–1034.
58. Perkins EM, Donnellan SC, Lester R, Bondad-Reantaso MG. Gallia F. New species of Benedenia Diesing, 1858 including a redescription of Benedenia mutabile Linton, 1910. Parasitology 1929, 21:220–225.
59. Gupta PC, Singh RB. Four new digenetic trematodes from marine fishes of the southern Great Barrier Reef, New Caledonia and the Maldives. Acta Parasitol 2001, 55:327–339.
60. Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. g. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
61. Miller TL, Cribb TH. Coevolution of Retrovarium n. gen. (Digenea: Cryptogonimidae) in Lutjanidae and Haemulidae (Percomorphae) in the Indo-West Pacific. Int J Parasitol 2007, 37:1023–1045.
62. Haefeltzallah M, Siddiqi A. H. Digenetic trematodes of marine fishes of India. Part I. Bucephalidae and Cryptogonimidae. Indian J Helminthol 1970, 22:1–22.
63. Miller TL, Adlard RD, Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. sp. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
64. Perkins EM, Donnellan SC, Lester R, Bondad-Reantaso MG. Gallia F. New species of Benedenia Diesing, 1858 including a redescription of Benedenia mutabile Linton, 1910. Parasitology 1929, 21:220–225.
65. Gupta PC, Singh RB. Four new digenetic trematodes from marine fishes of the southern Great Barrier Reef, New Caledonia and the Maldives. Acta Parasitol 2001, 55:327–339.
66. Bray RA, Webster BL, Bartoli P, Littlewood DTJ. Relationships within the Acanthocotylidae Luhe, 1906 and their place among the Digenea. Acta Parasitol 2005, 50:281–291.
67. Bray RA, Justine J-L. Acanthocotylidae (Digenea) of marine fishes off New Caledonia, with the descriptions of two new species. Folia Parasitol 2011, 58:35–47.
68. Bray RA, Cribb TH. Digeneans of the family Opecoelidae Ozaki, 1925 from the southern Great Barrier Reef, including a new genus and three new species. J Nat Hist 1989, 23:429–473.
69. McCoy OR. The life-history of a marine trematode, Hamacreadium mutable Linton, 1910. Parasitology 1929, 21:220–225.
70. Gupta PC, Singh RB. Four new digenetic trematodes from marine fishes off Puri coast, Bay of Bengal. Indian J Parasitol 1985, 29:25–34.
71. Gupta PC, Gupta VC. On three opecoelid trematodes (Digenea) from marine fishes, Bay of Bengal, India. Proc Parasitol 1988, 65:69–69.
72. Aken’ova TOL, Cribb TH. Two new species of Neolebouria Gibson, 1976 (Digenea: Opecoelidae) from temperate marine fishes of Australia. Syst Parasitol 2001, 49:55–71.
73. Bray RA, Justine J-L. Neolebouria blatta n. sp. (Digenea: Opecoelidae) from Percomorphae (Percomorphae: Haemulidae) from the surface of its host, Lutjanus carponotatus (Pisces: Lutjanidae). Parasitology 2002, 124:423–434.
74. Horton WA, Whittington ID. A new species of Metabenedenia (Monogenea, Capsalidae) from the dorsal fin of Diagramma pictum (Percomorphae, Haemulidae) from the Great Barrier Reef, Australia with a revision of the genus. J Parasitol 1994, 80:98–1007.
75. In FishBase. World Wide Web electronic publication. Edited by Froese R, Pauly D; 2012. www.fishbase.org.
76. Yamaquti S. New monogenetic trematodes from Hawaiian fishes, Il Pac Sci 1966, 20:694–694.
77. Bychowsky BL, Nagibina LF. New Capsalidae (Monogeneidea) from Pacific fishes. Parasitol Skol 1967, 1527–528.
78. Grutter AS. Spatial and temporal variations of the epcoratopine of seven reef fish species from Lizard Island and Heron Island, Australia. Mar Ecol Prog Ser 1994, 115:21–30.
79. Cribb TH, Bray RA, Olson PD, Littlewood DTJ. Life cycle evolution in the Digenea: a new perspective from phylogeny. Adv Parasitol 2003, 54:197–258.
80. Gibson DJ, Bray RA. The Hemiuridae (Digenea) of fishes from the north-east Atlantic. Bull Br Mus (Nat Hist) (Zool Ser) 1986, 81:1–125.
81. Miller TL, Bray RA, Gorian J, Justine J-L, Cribb TH. Adlaria novaezeelandiae n.g., n. sp. (Digenea: Cryptogonimidae) from the fork-tailed threadfin bream Nemipterus furcosus (Val.) (Percomorphae: Nemipteridae) off New Caledonia. Syst Parasitol 2009, 73:151–160.
82. Velasquez CC. Cryptogonimidae (Digenea: Trematoda) from Philippine food fishes. J Parasitol 1961, 47:914–918.
83. Manter HW. Studies in the digenetic trematodes of fishes of Fiji, III. Families Acanthocotylidae, Felidostomatidae, and Cryptogonimidae. J Parasitol 1963, 49:443–450.
84. Yamaquti S. Digenean trematodes of Hawaiian fishes. Tokyo: Keigaku; 1970.
85. Gupta PC, Shen J-W. Digenetic trematodes of fishes from the Xisha Islands, Guangdong Province, China. I. Stud Mar Sin 1983, 20(5):178–184. In Chinese.
86. Miller TL, Cribb TH. Coevolution of Retrovarium n. gen. (Digenea: Cryptogonimidae) in Lutjanidae and Haemulidae (Percomorphae) in the Indo-West Pacific. Int J Parasitol 2007, 37:1023–1045.
87. Macvicaria F. New species of the family Diplectanum (Monogeneidea, Diplectanidae). In: FishBase. World Wide Web electronic publication.
88. Miller TL, Adlard RD, Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. g. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
89. Miller TL, Adlard RD, Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. sp. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
90. Miller TL, Adlard RD, Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. sp. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
91. Miller TL, Adlard RD, Bray RA, Justine J-L, Cribb TH. Cryptic species of Euryakaina n. sp. (Digenea: Cryptogonimidae) from sympatric lutjanids in the Indo-West Pacific. Syst Parasitol 2010, 77:185–204.
96. Kuramochi T: Digenean trematodes of fishes caught in Sagami Bay, off Izu Islands and off Ogawasara Islands. Mem Natl Mus Nat Sci, Tokyo 2011, 47:51–63.

97. Korbataeva VD: New species of Trematoda of the genus Tergestia Stossich, 1899 (Trematoda, Fellodostomidae). Izv Tsirkolarskogo Nauchno-Issled Inst Rybn Khizh Kreni 1972, 81:263–266.

98. Okher P, Caia JR, Jensen K, Overstreet RM, Palm HW, Beveridge I: Evolution of the trypanorhynch tapeworms: Parasite phylogeny supports independent lineages of sharks and rays. Int J Parasitol 2010, 40:223–242.

99. Palm HW: The Trypanorhyncha Diesing, 1863. Bogor: PKPLJPB Press; 2004.

100. Andrews AH, Kalish JM, Newman SJ, Johnston JM: Parasite biodiversity in a coral reef fish: twelve species of Monogenea of chaetodontid fishes (Perciformes): implications of Hurleytrematoides (Cavisonidae) in New Caledonia. Mar Freshw Res 2011, 62:1259–1269.

101. Moravec F, Justine J-L: Tributellarians in fish parasites. Praha: Academia; 2006.

102. Santos Cavalcanti ET, Takemoto RM, Alves LC, Chellappa S: First record of endoparasite Phylometra sp. (Nematoda: Phylometridae) in lane snapper Lutjanus synagris (Pisces, Teleostei, Siganidae) (Valenciennes, 1835) from the Laughing gurnard (Sphyraena putnamae Jordan & Seale (Sphyraenidae)) from the Lagoon off New Caledonia. Syst Parasitol 2011, 79:123–138.

103. Justine J-L, Huffmaneia pectinome n. sp. (Nematoda: Trichosomoididae: Huffmaneinae) from the coralgroupers Plectropomus leopardus (Lacépède) off New Caledonia. Syst Parasitol 2011, 79:139–143.

104. Bosques Rodriguez L: Metazoan parasites of snappers, Lutjanidae (Pisces) from Puerto Rico. PhD thesis, University of Puerto Rico; 2004.

105. Bullard SA, Barse AM, Curran SS, Morris JA: Parasites of Lutjanus kahili (Platyhelminthes, Cestoda) from the blue-spotted stingray, Neotrygon kuhlii (Müller & Henle, 1841) off New Caledonia. Zoosystema 2010, 32:643–652.

106. Cannon LRG, Lester RJG: parasite dating of three important reef-fish species using Indo-Pacific 14C chronologies. Mar Freshw Res 2011, 62:1259–1269.

107. Beveridge I, Justine J-L: Two new species of Prochristianella Dollfus, 1946 (Platyhelminthes, Cestoda) from the blue-spotted stingray, Neotrygon kuhlii ( Müller & Henle, 1841) off New Caledonia. Zoosystema 2010, 32:643–652.

108. Bray RA, Cribb TH, Justine J-L: Multiresis Manter 1931 (Digenea: Lepocreadiidae) in ephippid and chaetodontid fishes (Perciformes) in the south-west Pacific Ocean and the Indian Ocean off Western Australia. Zootaxa 2010, 2427:36–46.

109. Bray RA, Cribb TH, Justine J-L: Diploproctotrema spp. (Digenea: Lepocreadiidae) in Australian and New Caledonian waters including two new species from Tetraodontiformes and new records of related species. Acta Parasitol 2010, 51:313–326.

110. Bray RA, Justine J-L: Bucephaline digeneticus (Bucephalidinae) in Sphyraena putnamae Jordan & Seale (Sphyraenidae) from the Lagoon off New Caledonia. Syst Parasitol 2011, 79:123–138.

111. Moravec F, Justine J-L: Two new genera and species of cystidicolids (Nematoda, Cystidicolidae) from marine fishes off New Caledonia. Parasitol Int 2010, 59:198–205.

112. Stork NE, Lyal CHC: Extinction or "co-extinction" rates. Nature 1993, 366:307–307.

113. Koh LP, Dunn RR, Sothi NS, Colwell RK, Proctor HC, Smith VS: Species coextinctions and the biodiversity crisis. Science 2004, 305:1632–1634.

114. Windsor DA: Equal rights for parasites. Conserv Biol 1995, 9:1–2.

115. Windsor DA: Most species of Earth are parasites. Int J Parasitol 1998, 28:1939–1941.

116. Dunn RR, Harris NC, Colwell RK, Koh LP, Sothi NS: The sixth mass coextinction: are most endangered species parasites and mutualists? Proc Roy Soc B Biol Sci 2009, 276:3037–3045.

117. Dobson A, Lafferty KD, Kurten AM, Hechinger RR, Zetz J: How many parasites are left? Proc Natl Acad Sci USA 2008, 105:11482–11489.

118. Róza L: Endangered parasite species. Int J Parasitol 1992, 22:265–266.

119. Justine J-L: Parasite biodiversity in a coral reef fish: twelve species of monogeneans on the gills of the grouper Epinephelus maculatus (Perciformes: Serranidae) off New Caledonia, with a description of eight new species of Pseudohabrobothynochus (Monogenea: Diplectrudontidae), Syst Parasitol 2007, 66:11–29.

120. Moir ML, Vesk PA, Brennan KE, Keith DA, Hughes L, McCarthy MA: Current constraints and future directions in estimating coextinction. Conserv Biol 2010, 24:682–690.

121. Mihalac A, Gherman C, Cozma V: Co-endangered hard-ticks: threatened or threatening? Parasites Vectors 2011, 4:71.

122. Cardoso P, Erwin TL, Borge PAV, New TR: The seven impediments in invertebrate conservation and how to overcome them. Biol Conserv 2011, 144:2647–2655.

123. Hughes TP: Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. Science 1994, 265:547–551.

124. Roberts CM, McClean CJ, Veron JEN, Hawkins JP, Allen GR, McAllister DE, Mittermeier CG, Schlueter PW, Spalding M, Wells F, et al. Marine biodiversity hotspots and conservation priorities for tropical reefs. Science 2002, 295:1280–1284.

125. Pandolfi JM, Bradbury RH, Sala E, Hughes TP, Bjorndal KA, Cooke RG, Jones GP, McCormick MI, Srinivasan M, Eagle JV: Global trajectories of the long-term decline of coral reef ecosystems. Science 2003, 301:955–958.

126. Cribb TH, Moravec F, Justine J-L, Briand MJ, Bray RA: Keys to the Cestode Parasites of Vertebrates. Wallingford: CAB International; 1994.
164. Kuchta R, Scholz T, Bracel J, Bray RA. Suppression of the tapeworm order **Pseudophyllidea** (Platyhelminthes: Eucestoda) and the proposal of two new orders, Bothriocephalida and Diphyllobothriidae. Int J Parasitol 2008; 38:49–55.

165. Healy CJ, Caia JA, Jensen K, Webster BL, Littlewood DTJ. Proposal for a new tapeworm order, Rhinebothriidae. Int J Parasitol 2009; 39:497–511.

166. Lovelink J, Justine JL. Phylogenetic relationships within the polyopisthocotylean monogeneans (Platyhelminthes) inferred from partial 28 S rDNA sequences. J Parasitol 2001; 3:391–401.

167. Justine JL. Non-monophyly of the monogeneans? Int J Parasitol 1998; 28:1653–1657.

168. Moravec F, Justine J-L, Rigby MC. Some philometrid nematodes (Philometridae), including four new species of Pentapodium aureofasciatus from New Caledonia, with the proposal of Lutjanus etelidis (Nematoda: Philometridae) from the marine fish Lutjanus vitta (Perciformes, Balistidae) and additional opecoelids parasitizing fishes from the waters off New Caledonia. Folia Parasitol 2011; 56:302–310.

169. Moravec F, Justine J-L, Raphidascaris, (Ichthyascaris) etelidis n. sp. (Digenea, Cestoda, Trypanorhyncha) from Australian fishes. Trans R Soc S Aust 1987; 111:189–194.

170. Chandra KJ. Two new species in the genus (Nematoda - Cucullanidae) from the Australian Region. Aust J Zool 1952, 4:229–252.

171. Campbell RA, Beveridge I. A revision of the family Disonidinae Kurtz, 1924 (Copepoda: Siphonostomatoida). Syst Parasitol 2008; 70:81–106.

172. Moravec F, Justine J-L. Raphidascaris (Ichthyascaris) etelidis n. sp. (Nematoda, Anisakidae), a new ascaridoid nematode from lutjanid fishes off New Caledonia. Zoosystems 2012, 34:131–142.

173. Boxshall GA, Lin CL-H, Ho J-S, Ohtsuka S, Vennmuth Maran BA, Justine J-L, A revision of the family Disonidinae Kurtz, 1924 (Copepoda: Siphonostomatoida). Syst Parasitol 2008, 70:81–106.

174. Moravec F, Justine J-L. Three trichinellid nematodes from marine fishes off New Caledonia, including description of Pseudocapillaria novaecedanensis sp. nov. (Capillariidae). Acta Parasitol 2010, 55:71–80.

175. Moravec F, Justine J-L. Cucullanid nematodes (Cucullanida: Cucullanidae) from deep-sea marine fishes off New Caledonia, including Dichylene etelidis n. sp. Syst Parasitol 2011, 78:95–108.

176. Moravec F, Justine J-L. Two new gonad-infesting Philometra species (Nematoda: Philometridae) from the marine fish Lutjanus vitia (Perciformes: Lutjanidae) off New Caledonia. Folia Parasitol 2011, 58:302–310.

177. Moravec F, Justine J-L. Raphidascaris (Ichthyascaris) etelidis n. sp. (Nematoda, Anisakidae), a new ascaridoid nematode from lutjanid fishes off New Caledonia. Zoosystems 2012, 34:131–142.

178. Boxshall GA, Huys R, Copepoda of New Caledonia. In: Compendium of Marine Species from New Caledonia (Vol Documents Scientifiques et Techniques III, Deuxième Édition, pp. 259–265). Edited by Payri CE, de Forges BR, Nouméa, New Caledonia: Institut de Recherche for the Développement; 2007. 435 pp + Color Plates.

179. Bray RA, Justine J-L. Pseudophycynoderoder tendu sp. nov. (Digenea, Opecoelidae) in the yellow-spotted triggerfish Pseudobalistes fuscus (Perciformes, Balistidae) and additional opecoelids parasitizing fishes from the waters off New Caledonia. Acta Parasitol 2007, 52:13–17.

180. Quilichini Y, Faota J, Justine J-L, Bray RA, Marchand B. Spuren ultrastruktur de der digenean Sphoderoina elongata (Platyhelminthes, Cryptogonimidae) intestinal parasite of Nemipterus fuscus (Pisces, Teleostei). Parasitol Res 2009, 105:87–95.

181. Moravec F, Justine J-L. Some philometrid nematodes (Philometridae), including four new species of Philometridae, from marine fishes off New Caledonia. Acta Parasitol 2008, 53:369–381.

182. Moravec F, Justine J-L, Rigby MC. Some camallanid nematodes from marine perciform fishes off New Caledonia. Folia Parasitol 2006, 53:223–239.

183. Bleeker P. Recherches sur les Crustacés de l’Inde Archipelagique II. Sur les Isopodes cymothoaidiens de l’Archipel Indien. Verhand Natuurkunde Ver., Batavia 1857, 2:20–40.

184. Monod T. Tanaiidea et Isopoda. Mission Robert-Ph. Dolfiss en Égypte. Mém Inst Égypte 1933, 21:161–264.

185. Milne Edwards H. Ordre des Copépodes. In: Histoire naturelle des Crustacés, comprenant l’anatomie, la physiologie et la classification de ces animaux. Volume 3. 1840–1841:529.

186. Heller C. Crustaceaean, Reise der Oesterreichischen Fregatte ‘Novara’ um die Erde 1865, Band I, 1867:1–280.

187. Pillai NK. Description of some Brachiella and Clapellovis with comments on Isobranchia Haegeard. Crustaceana 1968, Supplement 1:119–135.

188. Shino SM. Copepods parasitic on Japanese fishes. 5. Five species of the family Pandanidae. Rep Fish Far, Pref Univ-Mie 1954, 1:291–332.

189. Bychowsky BC, Nagibina LF. Some trichinellid nematodes from marine fishes of the dry Tortugas II. Trematodes. Syst Parasitol 1977; 4:285–340.

190. Vigueras IP. Some new species of digenean trematodes of the families Basilejevichidae and Dactylogyridae from marine fishes of the Philippine Islands. Proc Acad Sci Wash 1931, 3:95–103.

191. Egorova TP. A taxonomic review of the subfamily Benedeniinae (Monogeneida: Capsalidae). Parasitologia 1997, 438–451.

192. Yamaguti S. New monogenean trematodes from Hawaiian fishes. I. Pac Sci 1965, 3:55–95.

193. Bijukumar A. Digeneric trematode parasites of the flatfishes (Pleuronectiformes) of the Kerela coast, India. Acta Parasitol 1997, 42:149–157.

194. Linton E. Helminth fauna of the dry Tortugas II. Trematodes. Pap Tortugas Lab Carnegie Inst Washing 1910, 4:11–88.

195. Miller TL, Cribb TH. Family Cryptogonimidae Ward. In: Keys to the Trematoda, Volume 3. Edited by Bray RA, Gibson DJ, Jones A. Wallingford: CAB International; 2008, 3:258–112.

196. Vigueiras IP. Some trichinellid nematodes from marine fishes parasitic in marine fishes of the dry Tortugas. Syst Parasitol 1977; 4:285–340.

197. Yamaguti S. Studies on the helminth fauna of Japan. Part 2. Trematodes of fishes, I. Jap J Zool 1934, 5:249–541.

198. Campbell RA, Beveridge I. Floriceps minacanthus sp. nov. (Cestoda: Trypanorhyncha) from Australian fishes. Trans R Soc S Aust 1987, 111:189–194.

199. Sakanari J. Copepods parasitic in marine fishes. Publ Inst Mar Sci Uni Texas 1952, 2:175–215.

200. Petter AJ, Le Bel J. Two new species in the genus Cucullanus (Nematoda - Cucullanidae) from the Australian Region. Mém Inst Oswaldo Cruz, Rio de Janeiro 1992, 87(suppl. 1):201–206.
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