**Taxa, sources formations and age used in analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Taxon** | **Source(s)** | **Formation** | **Age for analysis** |
| *Hemicyclaspis*  *murchisoni* | ([Stensiö 1932](#_bookmark135)) | Ludlow, Shropshire.  Downtownian (Pridoli) | 421 |
| *Zenaspis salweyi* | ([Stensiö 1932](#_bookmark135)) | Lower old red sandstone. Skirrid Fawr, Senni/St  Maughans formation | 412 |
| *Cephalaspis lyelli* | ([Stensiö 1932,](#_bookmark135) [White](#_bookmark149)  [1958](#_bookmark149)) | Lower old red  sandstone, Glammis | 412 |
| *Benneviaspis*  *holtedahli* | ([Janvier 1985a](#_bookmark72)) | Ben Nevis formation,  Red bay group. | 413 |
| *Boreaspis*  *macrorhynchus* | ([Janvier 1985a](#_bookmark72)) | Wood bay formation | 411 |
| *Norselaspis glacialis* | ([Janvier 1981](#_bookmark73)) | Wood bay formation | 411 |
| *Nectaspis areolate* | ([Wängsjö 1952,](#_bookmark146) [Janvier](#_bookmark73)  [1981](#_bookmark73)) | Wood bay formation | 411 |
| *Procephalaspis oeselensis* | ([Robertson 1939,](#_bookmark125)  [Denison 1951,](#_bookmark28) [Janvier](#_bookmark74) [1985b](#_bookmark74)) | Saaremaa, Estonia. Wenlockian and  Ludlowian | 427 |
| *Tremataspis mammillata* | ([Robertson 1938a,](#_bookmark126) [Robertson 1938b,](#_bookmark127) [Denison 1947,](#_bookmark29) [Denison](#_bookmark28)  [1951,](#_bookmark28) [Janvier 1985b](#_bookmark74)) | Saaremaa | 427 |
| *Waengsjoeaspis*  *excellens* | ([Wängsjö 1952,](#_bookmark146) [Janvier](#_bookmark72)  [1985a](#_bookmark72)) | Fraenkelryggen  formation | 416 |
| *Escuminaspis laticeps* | ([Janvier et al. 2004](#_bookmark75)) | Escuminac formation | 380 |
| *Eugaleaspis changi* | ([Liu 1965,](#_bookmark84) [Zhu and Gai](#_bookmark165)  [2007](#_bookmark165)) | Xitun formation,  Liaojaoshan | 412 |
| *Hanyangaspis*  *guodingshanensis* | ([Zhu and Gai 2007](#_bookmark165)) | Guodingshan  formation. Telychian | 436 |
| *Polybranchiaspis*  *liaojiaoshanensis* | ([Liu 1965,](#_bookmark84) [Liu 1975](#_bookmark85)) | Xishancun and Xitun  formations | 415 |
| *Bannhuanaspis*  *vukhuci* | ([Janvier et al. 1993](#_bookmark76)) | Bac Bun formation | 411 |
| *Wenshanaspis zhichangensis* | ([Zhao et al. 2001](#_bookmark161)) | Posongchong  formation, Wenshan. Pragian | 409 |
| *Shuyu zhejiangensis* | ([Gai et al. 2011](#_bookmark46)) | Maoshan formation. Late Telychian to early  Wenlock | 433 |
| Polybranchiaspid sp.  (histological samples) | ([Wang et al. 2005](#_bookmark145)) | Xishancun and Xitun  formations | 415 |
| *Yunnanolepis* sp. (various taxa from  same formations) | ([Zhang 1980,](#_bookmark159) [Zhu 1996](#_bookmark163)) | Xishancun and Xitun formations | 415 |
| *Parayunnanolepis*  *xitunensis* | ([Zhang et al. 2001,](#_bookmark157) [Zhu](#_bookmark172)  [et al. 2012](#_bookmark172)) | Xitun formation | 412 |
| *Microbrachius dicki* | ([Hemmings 1978,](#_bookmark69) [Long](#_bookmark92)  [et al. 2015](#_bookmark92)) | Eday flagstone and John O’Groats sandstone. Lower-  Middle Givetian | 386 |
| *Bothriolepis* sp. | ([Young 1984](#_bookmark152))  MVP230985 | Gogo formation | 383 |
| *Bothriolepis canadensis* | ([Downs and Donoghue](#_bookmark34) [2009,](#_bookmark34) [Béchard et al.](#_bookmark6)  [2014](#_bookmark6)) | Escuminac formation | 380 |
| *Pterichthyodes milleri* | ([Hemmings 1978](#_bookmark69)) | Achanarras horizon, under upper Stromness flagst. Late  Eifelian | 389 |
| *Remigolepis walkeri* | ([Johanson 1997](#_bookmark81)) | Canowindra.  Famennian | 366 |
| *Diandongpetalichthys*  *liaojiaoshanensis* | ([Zhu 1991](#_bookmark162)) | Xishancun formation | 417 |
| *Quasipetalichthys haikouensis* | ([Liu 1991](#_bookmark82)) | Kunming; Shixiagou formation, Ninxia.  Givetian | 385 |
| *Eurycaraspis incilis* | ([Liu 1991](#_bookmark82)) | Haikou formation.  Givetian | 385 |
| *Lunaspis broili* | ([Gross 1961](#_bookmark59)) | Hunsrueck slate. Late Pragian to early  Emsian | 408 |
| *Macropetalichthys rapheidolabis.* (including Macropetalichthys sp. specimens used in  1963 and 1969) | ([Stensiö 1925,](#_bookmark134) [Stensiö](#_bookmark136)  [1963b,](#_bookmark136) [Stensiö 1969](#_bookmark138)) | Onondaga limetone. Eifelian | 390 |
| *Wuttagoonaspis fletcheri* | ([Ritchie 1973,](#_bookmark122) [Miles and](#_bookmark107) [Young 1977](#_bookmark107)).  AMF53610, AMF53631,  AMF53591, | Mulga Downs group. Emsian-Eifelian | 393 |
| *Groenlandaspis* sp. | MVP48873(AMF59808) , AMF59814, MVP48877/8 (AMF59811/2),  AMF62534A, AMF59809 | Mt. Howitt | 385 |
| *Cowralepis mclachlani* | ([Ritchie 2005,](#_bookmark124) [Carr et al.](#_bookmark14) [2009](#_bookmark14)) | Merriganowry shale. Late Givetian to early  Frasnian | 383 |
| *Gavinaspis convergens* | ([Dupret et al. 2009](#_bookmark38)) | Xitun formation. | 412 |
| *Sigaspis lepidophora* | ([Goujet 1973](#_bookmark54)) | Wood bay formation  (extreme base) | 412 |
| *Kujdanowiaspis podolica* | ([Stensiö 1963a,](#_bookmark137) [Dupret](#_bookmark36) [2010](#_bookmark36)) | Dnister series, Podolia. Upper Lockhovian-  lower Pragian | 411 |
| *Dicksonosteus arcticus* | ([Goujet 1975,](#_bookmark55) [Goujet](#_bookmark56)  [1984](#_bookmark56)) | Wood bay formation | 411 |
| *Buchanosteus*  *confertituberculatus* | ([Burrow and Turner](#_bookmark11)  [1998,](#_bookmark11) [Long et al. 2014](#_bookmark93)) | Buchan. Mid-late  Pragian | 408 |
| *Parabuchanosteus murrumbidgeensis* | ([White and Toombs](#_bookmark150) [1972,](#_bookmark150) [Young 1979,](#_bookmark154)  [Burrow and Turner](#_bookmark11)  [1998](#_bookmark11)) | Taemas-Wee Jasper | 401 |
| *Holonema westolli* | ([Miles 1971](#_bookmark103)) | Gogo formation | 383 |
| *Coccosteus cuspidatus* | ([Miles and Westoll](#_bookmark106) [1968](#_bookmark106)) | Achanarras and edderton fish bed. Eifelian-Givetain  boundary | 388 |
| *Incisoscutum ritchiei* | ([Dennis and Miles 1981,](#_bookmark31)  [Giles et al. 2013](#_bookmark53)) | Gogo formation | 383 |
| *Eastmanosteus*  *calliaspis* | ([Dennis-Bryan 1987](#_bookmark30)) | Gogo formation | 383 |
| *Compagopiscis*  *croucheri* | ([Gardiner and Miles](#_bookmark49)  [1994](#_bookmark49)) | Gogo formation | 383 |
| *Materpiscis*  *attenboroughi* | ([Long et al. 2008,](#_bookmark94)  [Trinajstic et al. 2012](#_bookmark143)) | Gogo formation | 383 |
| *Austroptyctodus*  *gardineri* | ([Long 1997a](#_bookmark88)) | Gogo Formation | 383 |
| *Campbellodus*  *decipiens* | ([Long 1997a](#_bookmark88)) | Gogo formation | 383 |
| *Rhamphodopsis threiplandi* | ([Miles 1967,](#_bookmark102) [Long](#_bookmark90) [1997b](#_bookmark90)) | Edderton fish beds. Eifelian-Givetian  boundary | 388 |
| *Brindabellaspis*  *stensioi* | ([Young 1980](#_bookmark155)).  ANUV3247 | Taemas-Wee Jasper | 401 |
| *Kolymaspis sibirica* | TsNIGR 7656 | Vechernyaya Formation | 400 |
| *Romundina stellina* | ([Ørvig 1975,](#_bookmark114) [Dupret et](#_bookmark37)  [al. 2014](#_bookmark37)) | Lockhovian. Prince of  Wales island. | 415 |
| *Jagorina pandora* | ([Stensiö 1969,](#_bookmark138) [Young](#_bookmark153)  [1986](#_bookmark153)) | Kellwasserkalk, Bad  Wildungen. Late Frasnian | 375 |
| *Gemuendina stuertzi* | ([Gross 1963](#_bookmark60)) | Hunsrueck slate | 408 |
| *Minjinia turgenensis* | ([Brazeau et al. 2020](#Brazeau_minjinia)) | Tsagaansalaa Formation (Baastuul Formation) | 410 |
| *Entelognathus*  *primordialis* | ([Zhu et al. 2013](#_bookmark170)) | Kuanti formation | 424 |
| *Janusiscus schultzei* | ([Giles et al. 2015b](#_bookmark52)) | Lower member, Kureika formation.  Middle Lockhovian. | 415 |
| *Ramirosuarezia*  *boliviana* | ([Pradel et al. 2009](#_bookmark117)) | Icla formation. Early  Eifelian | 392 |
| *Acanthodes bronni* | ([Gross 1935,](#_bookmark58) [Watson](#_bookmark147)  [1937,](#_bookmark147) [Miles 1973b,](#_bookmark105) [Miles 1973a,](#_bookmark104) [Coates](#_bookmark24) [1994,](#_bookmark24) [Davis et al. 2012,](#_bookmark26) [Brazeau and de Winter](#_bookmark9)  [2015](#_bookmark9)) | Lebach ironstone. Early Permian | 298 |
| *Brachyacanthus scutiger* | ([Watson 1937](#_bookmark147)) | Lower old red sandstone, Farnell.  Lockhovian | 415 |
| *Brochoadmones milesi* | ([Hanke and Wilson](#_bookmark65)  [2006](#_bookmark65)) | MOTH | 415 |
| *Cassidiceps*  *vermiculatus* | ([Gagnier and Wilson](#_bookmark43)  [1996](#_bookmark43)) | MOTH | 415 |
| *Cheiracanthus latus*/*murchisoni* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104) [1973a](#_bookmark104)) | Middle old red sandstone, Moray firth. Nodular fish  beds, Eifelian-Givetian | 388 |
| *Climatius reticulatus* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104)  [1973a](#_bookmark104)) | ‘Turin hill’ | 415 |
| *Culmacanthus stewarti* | ([Long 1983](#_bookmark86)) | Mt Howitt | 385 |
| *Euthacanthus macnicoli* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104) [1973a,](#_bookmark104) [Newman et al.](#_bookmark111)  [2014](#_bookmark111)) | ‘Turin hill’ | 415 |
| *Gladiobranchus*  *probation* | ([Hanke and Davis 2008](#_bookmark62)) | MOTH | 415 |
| *Homalacanthus*  *concinnus* | ([Gagnier 1996](#_bookmark44)) | Escuminac formation | 380 |
| *Ischnacanthus gracilis* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104)  [1973a](#_bookmark104)) | ‘Turin hill’ | 415 |
| *Kathemacanthus rosulentus* | ([Gagnier and Wilson](#_bookmark43)  [1996,](#_bookmark43) [Hanke and Wilson](#_bookmark67) [2010](#_bookmark67)) | MOTH | 415 |
| *Latviacanthus*  *ventspilensis* | ([Schultze and Zidek](#_bookmark133)  [1982](#_bookmark133)) | Ventspils. Kemeri  stage | 404 |
| *Lupopsyrus pygmaeus* | ([Hanke and Davis 2012](#_bookmark63)) | MOTH | 415 |
| *Mesacanthus mitchelli* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104)  [1973a](#_bookmark104)) | ‘Turin hill’ and Farnell | 415 |
| *Obtusacanthus*  *corroconis* | ([Hanke and Wilson](#_bookmark66)  [2004](#_bookmark66)) | MOTH | 415 |
| *Parexus recurvus* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104) [1973a,](#_bookmark104) [Burrow et al.](#_bookmark12)  [2013](#_bookmark12)) | ‘Turin hill’ | 415 |
| *Poracanthodes menneri* | ([Valiukevicius 1992](#_bookmark144)) | Severnaya Zemlya  formation. Lower Lockhovian. | 417 |
| *Promesacanthus*  *eppleri* | ([Hanke 2008](#_bookmark61)) | MOTH | 415 |
| *Ptomacanthus anglicus* | ([Miles 1973a,](#_bookmark104) [Brazeau](#_bookmark8)  [2012](#_bookmark8)) | Wayne Herbert  quarry, Lockhovian | 415 |
| *Diplacanthus striatus* | ([Watson 1937,](#_bookmark147) [Miles](#_bookmark104) [1973a](#_bookmark104)) | Moray firth and Achanarras. Eifelian-  Givetian boundary | 388 |
| *Tetanopsyrus*  *lindoei*/*breviacanthus* | ([Gagnier et al. 1999,](#_bookmark45)  [Hanke et al. 2001](#_bookmark64)) | MOTH | 415 |
| *Dobunnacanthus*  *waynensis* | ([Miles 1973a](#_bookmark104), [Dearden et al. 2021](#Dearden_vernicoma_2021)) | Wayne Herbert quarry | 415 |
| *Cladodoides*  *wildungensis* | ([Maisey 2005](#_bookmark100)) | Wildungen limestone,  Upper Frasnian | 375 |
| *Akmonistion zangerli* | ([Coates and Sequeira](#_bookmark21) [1998,](#_bookmark21) [Coates et al.](#_bookmark23)  [1998,](#_bookmark23) [Coates and](#_bookmark22)  [Sequeira 2001](#_bookmark22)) | Manse Burn formation, Bearsden. Serpukhovian | 327 |
| “*Cobelodus*” | ([Maisey 2007](#_bookmark101)) | Fayetteville formation.  Chesterian | 325 |
| *Cladoselache kepleri*/*fyerli* | ([Harris 1938,](#_bookmark68) [Bendix-](#_bookmark7)  [Almgreen 1975,](#_bookmark7)  [Schaeffer 1981,](#_bookmark130) [Maisey](#_bookmark101)  [2007](#_bookmark101)) | Cleveland member of Ohio Shale. Late Famennian | 360 |
| *Chondrenchelys problematica* | ([Moy-Thomas 1935,](#_bookmark109) [Finarelli and Coates](#_bookmark39) [2011,](#_bookmark39) [Finarelli and](#_bookmark40)  [Coates 2014](#_bookmark40)) | Glencartholm, Scotland. Visean (Holkerian) | 338 |
| *Helodus simplex* | ([Moy-Thomas 1936](#_bookmark110)) | Fenton, Staffordshire.  Moscovian | 311 |
| *Debeerius ellefseni* | ([Grogan and Lund 2000](#_bookmark57)) | Bear Gulch limestone.  Upper Chesterian | 320 |
| *Doliodus problematicus* | ([Miller et al. 2003,](#_bookmark108) [Maisey et al. 2009](#_bookmark97)) | ‘Atholville beds’, Campbellton formation. Emsian or  Emsian-Eifelian | 395 |
| *Hamiltonichthys mapesi* | ([Maisey 1989](#_bookmark98)) | Hartford limetone, Hamilton quarry.  Middle Virgilian | 302 |
| *Onychoselache traquari* | ([Dick and Maisey 1980,](#_bookmark32) [Coates and Gess 2007](#_bookmark27)) | Glencartholm volcanic beds and Wardie shales. Holkerian-  Asbian | 336 |
| *Orthacanthus* sp. | ([Schaeffer 1981](#_bookmark130)) | Admiral formation.  Wolfcampian | 290 |
| *Pucapampella rodrigae*/sp. | ([Maisey 2001](#_bookmark99)) | Sica sica formation,  Bolivia. Eifelian- Givetian | 388 |
| *Tamiobatis vetustus* | ([Schaeffer 1981,](#_bookmark130)  [Williams 1998](#_bookmark151)) | Cleveland shale (Famennian) and Salem limestone (Early  Visean) | 360 |
| *Tristychius arcuatus* | ([Dick 1978,](#_bookmark33) [Coates and](#_bookmark27) [Gess 2007](#_bookmark27)) | Wardie shales and Manse burn  formation, Bearsden | 336 |
| *Dialipina*  *salgueiroensis* | ([Schultze 1968,](#_bookmark131) [Schultze](#_bookmark132)  [and Cumbaa 2001](#_bookmark132)) | Bear Rock formation.  Emsian | 401 |
| *Ligulalepis toombsi* | ([Schultze 1968,](#_bookmark131) [Burrow](#_bookmark10) [1994,](#_bookmark10) [Basden et al.](#_bookmark5)  [2000,](#_bookmark5) [Basden and Young](#_bookmark4)  [2001](#_bookmark4)) | Taemas-Wee Jasper | 401 |
| *Cheirolepis canadensis* | ([Pearson and Westoll](#_bookmark116) [1979,](#_bookmark116) [Arratia and](#_bookmark3)  [Cloutier 1996](#_bookmark3)) | Escuminac formation | 380 |
| *Cheirolepis trailli* | ([Pearson and Westoll](#_bookmark116) [1979,](#_bookmark116) [Giles et al. 2015a](#_bookmark50)) | Achanarras limestone, Tynet burn and  Gamrie. Late Eifelian | 388 |
| *Howqualepis*  *rostridens* | ([Long 1988](#_bookmark89)) | Mt. Howitt | 385 |
| *Mimipiscis toombsi* | ([Gardiner and Bartram](#_bookmark47) [1977,](#_bookmark47) [Gardiner 1984,](#_bookmark48) [Giles and Friedman](#_bookmark51)  [2014](#_bookmark51)) | Gogo formation | 383 |
| *Moythomasia*  *durgaringa* | ([Gardiner 1984](#_bookmark48)) | Gogo formation | 383 |
| *Kentuckia deani* | ([Rayner 1952,](#_bookmark121) [Giles and](#_bookmark51) [Friedman 2014](#_bookmark51)) | New Providence Shale member, Stockdale formation. Latest Tournasian or earliest  Visean | 347 |
| *Osorioichthys marginis* | ([Taverne 1997](#_bookmark140)) | Femenne formation.  Early Femennian | 367 |
| *Meemannia eos* | ([Zhu et al. 2006,](#_bookmark174) [Zhu et](#_bookmark166)  [al. 2010](#_bookmark166)) | Xitun formation | 412 |
| *Guiyu oneiros* | ([Zhu et al. 2009,](#_bookmark175) [Qiao](#_bookmark119)  [and Zhu 2010](#_bookmark119)) | Kuanti formation | 424 |
| *Psarolepis romeri* | ([Yu 1998,](#_bookmark156) [Zhu et al.](#_bookmark173) [1999,](#_bookmark173) [Zhu and Yu 2004,](#_bookmark168) [Zhu and Yu 2009](#_bookmark169)) | Xishancun, Xitun and Yulongsi formations. Also Silurian. Most material used to score characters is from  Xishancun formation. | 416 |
| *Achoania jarvikii* | ([Zhu et al. 2001,](#_bookmark171) [Zhu](#_bookmark168) [and Yu 2004,](#_bookmark168) [Zhu and](#_bookmark169)  [Yu 2009](#_bookmark169)) | Xitun formation | 412 |
| *Onychodus*  *jandemarrai* | ([Andrews et al. 2005](#_bookmark1)) | Gogo formation,  Saddler formation | 383 |
| *Miguashaia bureaui* | ([Cloutier 1996,](#_bookmark20) [Forey](#_bookmark41)  [1998](#_bookmark41)) | Escuminac formation | 380 |
| *Styloichthys changae* | ([Zhu and Yu 2002,](#_bookmark167)  [Friedman 2007](#_bookmark42)) | Xitun formation | 412 |
| *Diabolepis speratus* | ([Chang and Yu 1984,](#_bookmark17)  [Chang 1995](#_bookmark16)) | Xitun formation | 412 |
| *Youngolepis praecursor* | ([Zhang and Yu 1981,](#_bookmark158) [Zhang 1982,](#_bookmark160) [Chang](#_bookmark15)  [1991](#_bookmark15)) | Xitun formation | 412 |
| *Powichthys thorsteinssoni* | ([Jessen 1980](#_bookmark79)) | Late lockhovian or early Pragian. Prince  of Wales island | 411 |
| *Porolepis* sp. (includes *elongata*, *brevis* and  *spitzbergensis*) | ([Jarvik 1972,](#_bookmark77) [Clement](#_bookmark19)  [2004](#_bookmark19)) | Wood bay formation | 411 |
| *Glyptolepis groenlandica* | ([Jarvik 1972,](#_bookmark77) [Ahlberg](#_bookmark0)  [1989](#_bookmark0)) | Red siltstone member of the Nathorst Fjord group. Late Eifelian-  Early Givetian | 388 |
| *Kenichthys campbelli* | ([Chang and Zhu 1993,](#_bookmark18) [Zhu and Ahlberg 2004](#_bookmark164)) | Chuangdong formation. Late  Emsian | 396 |
| *Osteolepis*  *macrolepidotus* | ([Westoll 1936,](#_bookmark148) [Thomson](#_bookmark141)  [1965,](#_bookmark141) [Jarvik 1980](#_bookmark78)) | Tynet burn. Late  Eifelian | 388 |
| *Gogonasus andrewsi* | ([Long 1985,](#_bookmark87) [Long et al.](#_bookmark91) [1997,](#_bookmark91) [Long et al. 2006,](#_bookmark95)  [Holland 2013,](#_bookmark70) [Holland](#_bookmark71)  [2014](#_bookmark71)) | Gogo formation | 383 |
| *Eusthenopteron foordi* | ([Jarvik 1980](#_bookmark78)) | Escuminac formation | 380 |

**Key of prefixes in character list**

“MDB”=Brazeau, M.D. 2009.

“DFC”= Davis et al. 2012.

“ZHU”= Zhu et al. 2013.

“DUPRET”= Dupret et al. 2014.

“LONG”= Long et al. 2015.

“GFB”= Giles et al. 2015.

“BW”= Brazeau and de Winter 2015.

“LU” =Lu et al. 2016

“RSS”=Sansom 2009.

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