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# THE RELATIONSHIP OF PREARTICULAR LENGTH AND STANDARD LENGTH IN PYCNODONTIFORM FISHES

***[Relaciones entre la longitud prearticular y la longitud estándar en los peces Pycnodontiformes]***

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**RESUMEN**: Los peces Pycnodontiformes son un grupo muy conocido, presente en numerosas colecciones de todo el mundo. Se les conoce entre el Triásico Superior y el Eoceno, y algunos géneros tienen una amplia distribución a escala mundial. Han sido muy estudiados en los dos últimos siglos, pero la mayoría de los trabajos tratan sobre taxonomía, siendo raros los que versan sobre paleobiología. En este artículo se presenta un método que relaciona la longitud estándar con la longitud prearticular. El principal resultado es una correlación positiva para los géneros *Gyrodus* y *Proscinetes* de la Baja Sajonia (NO de Alemania) y de la zona de Solnhofen (S de Alemania), para futuros estudios paleobiológicos.

Palabras clave: Pycnodontiformes, paleobiología, longitud estándar, NO Alemania, Solnhofen.

**ABSTRACT**: Pycnodontiform fishes are a well-known group, represented in many conservation Lagerstätten worldwide. They occur from the Late Triassic to the Eocene, and some genera were distributed worldwide. Much work has been done during the last centuries, but most scientists studied the taxonomy. The palaeobiology of the Pycnodontiformes has been rarely the central question in their publications. This paper presents a method to reconstruct the standard length by the means of the prearticular length. The main result is a positive correlation between the prearticular length and the standard length, that it

 

is possible to reconstruct the standard length of *Gyrodus* and *Proscinetes* from Lower-Saxony (NW-Germany) and the Solnhofen area (S-Germany) for paleobiological studies.

Key words: Pycnodontiformes, palaeobiology, standard length, NW-Germany, Solnhofen.

## INTRODUCTION

Pycnodontiform fishes are a Mesozoic group of neopterygian, which existed for about 175 million years, ranging from the late Triassic to the Eocene (e. g. Tintori, 1981; Poyato-Ariza & Wenz, 2002; Poyato-Ariza, 2003; Kriwet & Schmitz, 2005). Most Pycnodontiformes are small to medium sized fishes with a standard body length of about 25 cm or less (pers. observ.). A few taxa with a standard length of more than 50 cm are known. They are distinctive in their high and rounded body, normally elongated dorsal and anal fins and especially in possession of durophagous teeth on the vomer and the prearticular (see figures 1 & 2). About 80 species have been described so far based on skeletal remains, but about 650 species are known by their specialised teeth or dentitions (e. g. Poyato-Ariza & Wenz, 2002; Poyato-Ariza, 2003; Kriwet, 2004; Delsate & Kriwet, 2004). Teeth are generally arranged in more or less regular rows and cover most of the occlusal surfaces of the unpaired vomer and paired prearticulars.

The distribution of pycnodontiform fishes is worldwide during the Mesozoic (e. g. Solnhofen area in Germany, Las Hoyas in Spain, Tepexi de Rodríguez in Mexico and Lebanon) (e. g. Poyato-Ariza & Wenz, 2002, 2005; Poyato-Ariza, 2003; Kriwet & Schmitz, 2005). Generally, pycnodontiform remains occur in shallow-waters, continental-shelf environments and reef-areas (Nursall, 1996a; Kriwet, 2000). They are similar to recent coral fishes like Chaetodontidae, Acanthuridae, Balistidae or Scaridae in their overall morphology (Nursall, 1996a; Kriwet, 2005).

Much research has been conducted during the last centuries, but mostly of pure taxonomic nature (e. g. Agassiz, 1837-1843; Wagner, 1851, 1861; Winkler, 1862; Fricke, 1876; Hennig, 1906; Saint-Seine, 1949; Lambers, 1991; Frickhinger, 1991, 1994; Nursall, 1996b, 1999; Kriwet, 2000). Rare studies consider their palaeobiology (e. g. Hennig, 1906; Nursall, 1996a; Kriwet, 2001; Kriwet & Schmitz, 2005). For the present study, two genera of pycnodontiform fishes are considered. The first is *Gyrodus*, a common pycnodont in all conservation Lagerstätten of Europe (Kriwet & Schmitz, 2005). The specimens of *Gyrodus* reached more than one metre in standard length (pers. observ.). The characteristic teeth of *Gyrodus* (see figure 1) are mostly found in shallow marine, near-coastal deposits. The caudal fin form bears resemblance to modern Thunnidae or Carangidae (Nursall, 1996a). Therefore it can be assumed that members of this genus could have had a pelagic lifestyle with temporal occurrence in reefs. This can also be seen in the distribution of *Gyrodus* during its life period. In the upper Jurassic, its distribution is worldwide (Kriwet & Schmitz, 2005).

 

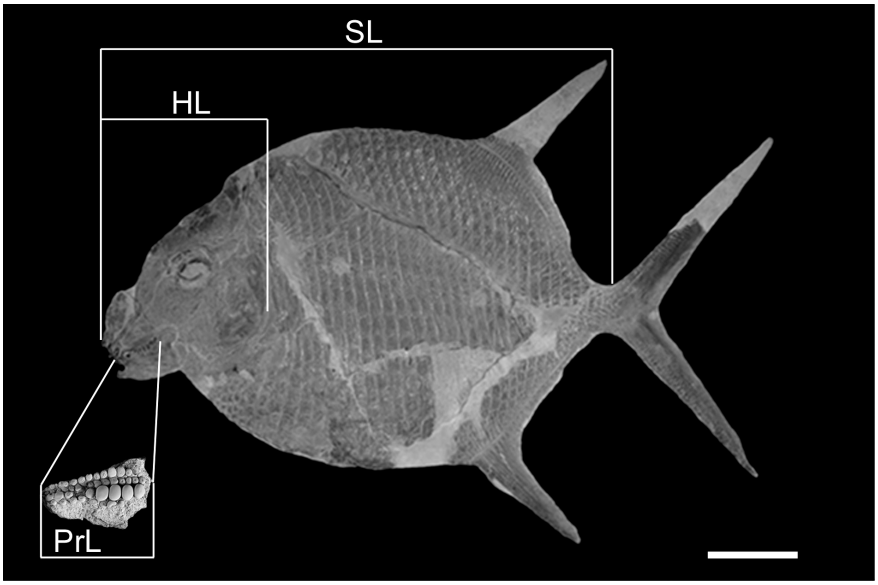


*Figure 1.* Gyrodus *(GZG.V.11210) with prearticular and its SL, HL and PrL (scale bar 5 cm).*

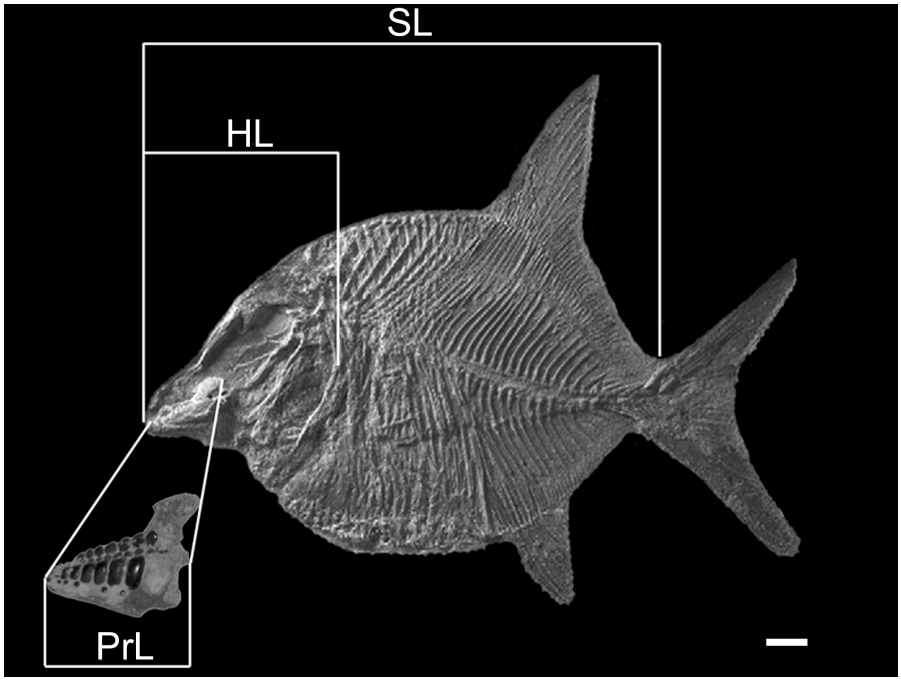


*Figure 2.* Proscinetes *(from* Fürsich et al.*, 2007: 105, fig.10b) with prearticular and its SL, HL and Pr (scale bar 1 cm).*

 

The second genus, which is employed in this study, is *Proscinetes*. This group of pycnodont fishes has a body form like typical Pycnodontiformes (see figure 2). Main differences, for instance, is the reduced squamation and dentition of *Proscinetes*. It is also a common pycnodont in all European conservation Lagerstätten during the Late Jurassic, but it is a group of fishes with a smaller standard length (Licht, 2008; Licht & Schmücker, 2008). The main standard length, measurable in this study, is about 7 to 30 cm. The intention of this paper is to present a method to reconstruct the standard length by using the prearticular and head length of pycnodontiform fishes, and its relevance for reconstructing their palaeobiology.

## MATERIALS AND METHODS

For this work, Late Jurassic Pycnodontiformes from Lower Saxony (NW-Germany) and the Solnhofen area (S-Germany) are used. Two genera, *Proscinetes* and *Gyrodus*, were examined. Taxonomic identification follows Poyato-Ariza & Wenz (2002). Prearticulars from NW-Germany are from five localities [Duingen (near Hildesheim); Holzen (near Hildesheim); Lindenerberg (Hanover); Marienhagen (Hildesheim) and Tönjesberg (Hannover)] (see

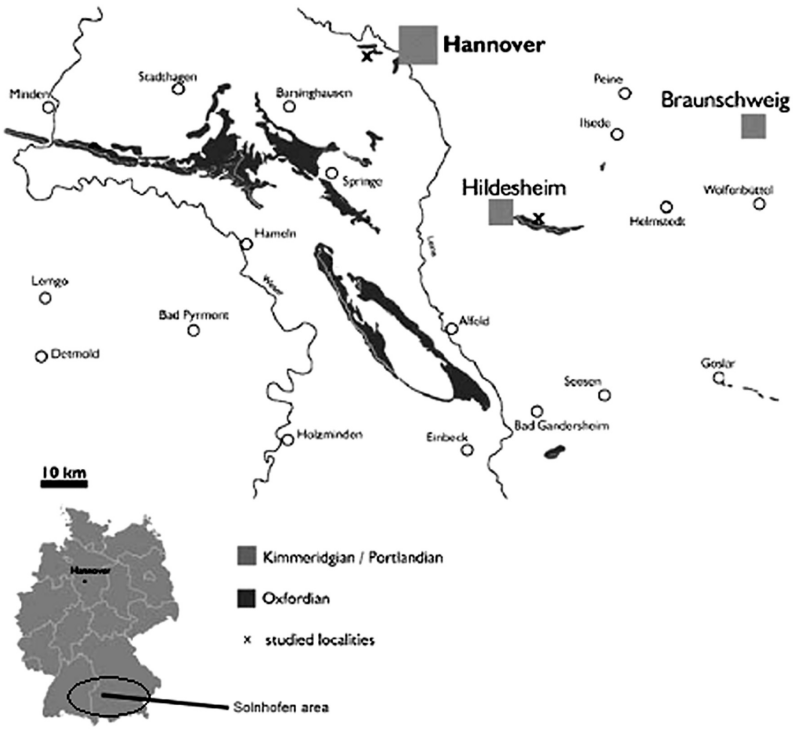


*Figure 3. Location map showing the distribution of Upper Jurassic strata exposed in NW-Germany.*

figure 3). All 68 prearticulars are deposited in the Museum of the Geoscience Centre of the University of Göttingen (see table 1). A total of 43 examples and additional 7 prearticulars from the Solnhofen area were included in the analyses. Exact localities could not be determined for S-Germany. The S-German specimens are stored in the Museum of the Geoscience Centre of the University of Göttingen, Museum for Natural History Berlin and in private collections. Standard length (SL), head length (HL) and prearticular length (PrL) are scaled (in cm) and statistically evaluated with the T-Test and the Pearson-Correlation. In some specimens, only the head and fragments of the body are preserved, and therefore the HL is used in addition.

## RESULTS

Table 2 shows the results of the statistical tests. For *Gyrodus*, significant results are recognisable. The PrL and the HL have a significant correlation. The result for the Pearson-Correlation is 0.98. The statistical result for the T-Test is significant with 9.66E-7 for P-one-sided and 1.93E-6 for P-double-sided. The same result for the Pearson-Correlation (0.98) is recognisable in

| | ***Proscinetes* sp.** | ***Gyrodus* sp.** |
|---|---|---|
| **NW-Germany** | | |
| Holzen | 3 | 10 |
| Duingen | 0 | 1 |
| Lindenerberg | 3 | 1 |
| Marienhagen | 3 | 0 |
| Tönjesberg | 44 | 0 |
| ? | 0 | 3 |
| **S-Germany** | | |
| | 13 | 37 |

*Table 1. Places of findings with the number of examined prearticulars of NW-Germany and S-Germany.*

| Genera | Length (cm) | mean | variance | n | Pearson-Correlation | P-onesided | P-doublesided |
|---|---|---|---|---|---|---|---|
| ***Gyrodus* sp.** | PrL | 2.26 | 5.94 | 35 | 0.98 | 9.66E-07 | 1.93186E-06 |
| | HL | 7.07 | 53.74 | 35 | | | |
| ***Gyrodus* sp.** | PrL | 2.43 | 8.07 | 24 | 0.98 | 5.3545E-05 | 0.00010709 |
| | SL | 21.34 | 512.85 | 24 | | | |
| ***Gyrodus* sp.** | HL | 7.96 | 75.03 | 24 | 0.98 | 6.3739E-05 | 0.000127479 |
| | SL | 21.34 | 512.85 | 24 | | | |
| ***Proscinetes* sp.** | PrL | 2.18 | 0.99 | 9 | 0.84 | 5.0978E-05 | 0.000101956 |
| | HL | 6.45 | 6.53 | 9 | | | |
| ***Proscinetes* sp.** | PrL | 2.18 | 0.99 | 9 | 0.94 | 6.1136E-05 | 0.000122273 |
| | SL | 16.33 | 50 | 9 | | | |
| ***Proscinetes* sp.** | HL | 6.45 | 6.53 | 9 | 0.92 | 0.00013906 | 0.00027811 |
| | SL | 16.33 | 50 | 9 | | | |

*Table 2. Statistical results of the Pearson-Correlation and the T-Test for* Gyrodus *and* Proscinetes.

the relation between PrL and SL. These two lengths also have a significant result for the T-Test (see table 2). The comparison between the HL and the SL for *Gyrodus* show exactly the same result for the Pearson-Correlation (0.98) as for PrL-HL and PrL-SL. The result of the T-Test of HL-SL is also significant, as for the other two comparisons (see table 2).

*Proscinetes* does not have such a good result for the Pearson-Correlation (0.84) for PrL-HL as it is for *Gyrodus*. However the relation between these two lengths is significant. The results for the T-Test show a significance of 5.1E-5 (P-one-sided) and 0.0001 (P-double-sided). The comparison between the Prl and SL of *Proscinetes* displays a much better result for the Pearson-Correlation (0.94) than for PrL with HL. Nearly the same result (0.92) is recognizable for the correlation between the HL and SL. Also both (PrL-SL and HL-SL) are significant in the T-Test (see table 2).

## ALLOCATION IN GROUPS

Some of the marks in the figures do not fit exactly on the regression line (see figures 4 & 5). Thus, the regression line is subdivided into groups individual for the different genera. Four groups of plots are present for *Gyrodus* (group 1: <24 cm; group 2: 24 cm-50 cm; group 3: 50 cm-80 cm; group 4: >80 cm) and for *Proscinetes* three groups (group 1: <15 cm; group 2: 15 cm-25 cm; group 3: >25 cm) are present. These groups are fictive and have only been created for the better handling and interpretation of the results. Further information for the cause is given in the section discussion and conclusions.

In Figure 6 the relation between the PrL and the SL for both genera is given. The result for both is 0.98 for the Pearson-Corelation and a significance of 7.99E-7 (P-one-sided) and 1.6E-6 (P-double-sided) for the T-Test (see table 2).

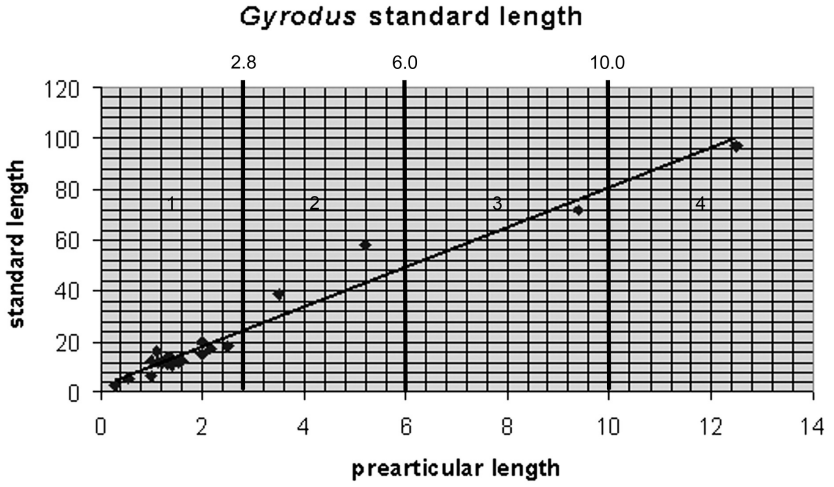


*Figure 4. Correlation between the PrL and the SL of* Gyrodus *with the four groups.*

The genera *Gyrodus* shows differences in the standard length between NW-Germany and S-Germany. In NW-Germany the average length is 6.06 cm and in S-Germany 2.47 cm. Conversely *Gyrodus*, *Proscinetes* do not display significant differences between these two areas. In NW-Germany the average length is 2.31 cm and in S-Germany 2.24 cm.

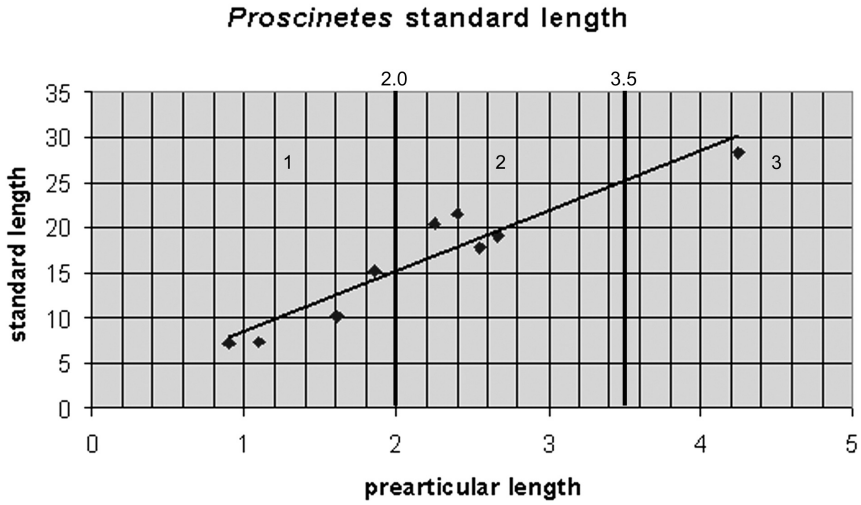


*Figure 5. Correlation of the PrL and the HL of* Proscinetes *with the three groups.*

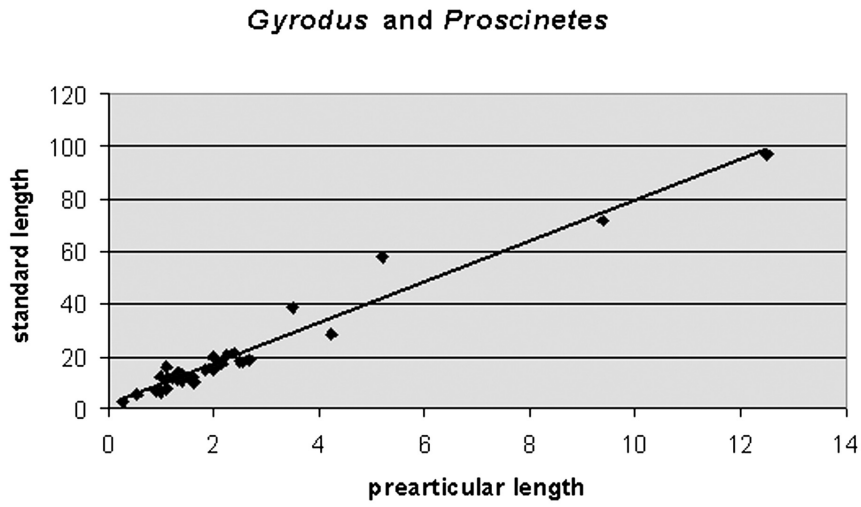


*Figure 6. Correlation between the PrL and the SL of both genera.*

## DISCUSSION

As exemplified in table 2 and figures 4-6 a significant correlation between PrL, HL and SL is obvious. These results cannot be discussed further because of their statistical significance. There are some problems with the method of reconstructing the SL that have to be considered, such as the numbers of run-off ballots. Not many examples were examined in this work, because many prearticulars in the collections could not be determined with certainty, but the statistical results show a trend and it is doubtful that this will be better with more run-off ballots. The comparison of PrL and SL display a possible correlation between both lengths (see figure 6). This correlation can be assumed for all Pycnodontiformes. *Gyrodus* and *Proscinetes* were used in this study because sufficient material was accessible that shows the whole skeleton with prearticulars. Both genera are also representative pycnodonts in NW-Germany and S-Germany (e. g. Licht & Reich, 2007; pers. observ.). It is very complicated to determine the species by means of teeth in pycnodontiform fishes (pers. observ.). Consequently, this study uses genera as lowest taxonomic unit. It is not to establish whether different, small and large species are mixed in the analysis or whether it is a growth series of a single species. However, a specific analysis is beyond the scope of this paper.

The separation of the results of the correlation/regression into groups is due to the circumstance that a comparison is better to handle. An example is the question of the disagreement between NW-Germany and S-Germany. The results show a different SL for *Gyrodus* between these two areas (Licht & Schmücker, 2008). These results, based on this method can be used to study the palaeobiology of pycnodonts. It is possible to answer new questions about the effects on their SL (e. g. predators, environment, nutrition). This method can be used for local spots, too. It is possible to examine these spots like in studies on extant reef-fishes (e. g. Shulman, 1985; Robertson, 1996, 1998). Licht (2008) and Licht & Kriwet (in prep.) give an example for this and try to answer some questions, like different preferences of individual pycnodont genera. Especially different habitat preferences between large and small individuals and possible intra- or interspecific competition are the main questions, which build the focus for future research.

This method enables us to answer and interpret palaeobiological questions concerning the pycnodontiform fishes. It is possible to reconstruct their biology and it brings a little light into the life of this group of fishes.

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