Mechanical Advantage in the Pit Bull Jaw

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ABSTRACT

In this study, I am attempting to determine if the jaws of the pit bull possess a mechanical advantage over the jaws of other domestic breeds of dog (Canis familiaris). My data base consists of forty-nine skulls, three of which are Pit Bulls. All measurements were taken either directly from the skulls and jaws themselves, or were interpreted from photographs. I eliminated differences in the results due to size by combining sets of measurements as ratios and comparing these ratios. After graphing and analyzing the derived ratios, I have found no evidence of mechanical advantage in the pit bull as compared to other domestic breeds of dog

INTRODUCTION

The American Pit Bull Terrier is a unique breed of dog with no specific background. Many owners and breed "experts" claim that the breeds existence can be traced back through art and historical writings to the early days of civilization.(Stratton 1976) However the Pit Bull's history is generally traced back to early 19th century Staffordshire England, where miners began breeding bulldogs, terriers, and other similarly physiqued dogs to create a breed best suited for the sport of dogfighting.(Swift 1986)

The Pit Bull first appeared in the United States in the late 1800's and soon became "Americas' dog". Artist Wallace Robinson used the Pit Bull to represent America in a W.W. I political cartoon and president Theodore Roosevelt owned a Pit Bull while he was in the White House.(Swift 1986) The Pit Bull was considered the perfect family pet and an exceptional companion for children. Buster Brown and the kids of "Our Gang" both had Pit Bull sidekicks.

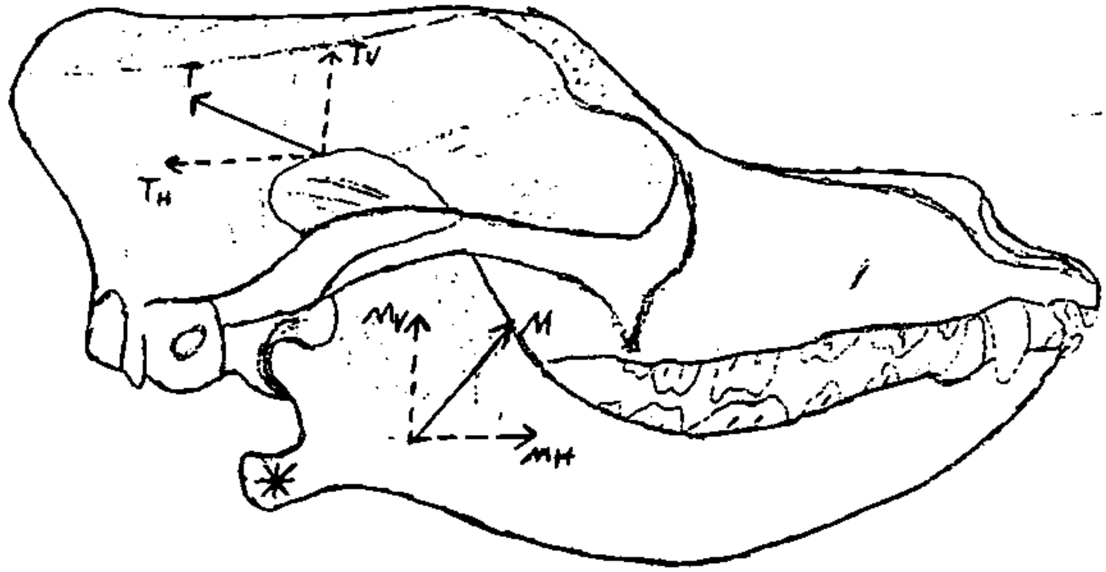
Recently though, the Pit Bull has received a reputation as a vicious killer. This reputation is a result of numerous attacks on humans, several of which have resulted in the death of the victim. Because of this new reputation, the Pit Bull has received a tremendous amount of publicity across the nation, labeling it "the macho dog to have"(Uehling and Hutchisons, 1986) and "the most dangerous dog in America"(Satchell and Shryer, 1987). This publicity has resulted in many communities attempting to ban the breed or place severe restrictions on ownership. The ensuing legal battle between dog lovers and those attempting to ban the breed has created one question which must be answered.

Is the Pit Bull's fighting ability a result of the handling and training of owners, many of whom participate in the illegal sport of dogfighting, or is it related to a structural difference in the breed? In order to answer this question, many people have begun to analyze the bite of the Pit Bull.

The three areas in which an animals bite can be analysed are cranial muscle mass analysis, clinical bite strength testing, and biomechanics.

The Biomechanics of the jaw can be used to determine if the Pit Bull has a mechanical advantage in biting as compared to other breeds of dog. The study of mechanical advantage has been used in several different ways. Greaves (1974) used a classic model in his study of the mammalian jaw joint while Bramble (1978) used an unorthodox method in his study of the mammalian feeding complex. Mechanical advantage has also been applied to fossils. Emerson and Radinski (1980) used it in their study of sabertooth cranial morphology and Ostrum (1964) used it to study the feeding adaptations in ceratopsian dinosaurs.

Mechanical advantage in the jaw can be considered as any structural difference which would allow the animal to produce or maintain a relatively greater force in biting. The major forces in the canine jaw are produced by the temporalis and masseter muscles (Alexander, 1968). The forces created by these muscles can be broken down into vector components (figure 1). The temporalis, which arises from the sagital crest and inserts on the coronoid process, has a vertical component and a posteriorly oriented horizontal component. The masseter, which arises under the zygomatic arch and inserts on the side of the mandible, has a vertical component and an anteriorly oriented horizontal component. An increase in the amount of force produced while biting could be



<u>Figure 1</u> : A sketch of the forces produced by the temporalis (T) and the masseter (M) along with their vertical (Tv, Mv) and horizontal (Th, Mh) vector components. The retro-articular stabilization process is marked by the asterisk.

accomplished by increasing the vertical components of either the temporalis or the masseter. An increase in the horizontal component of the temporalis, or an increase in the stability provided by the retro-articular stabilization process(figure 1), would increase the stability of the cranial mandibular jaw joint. By increasing this stability, the jaw would be able to maintain a stronger bite without risking dislocation of the jaw joint. Any increase in the horizontal component of the masseter would result in a destablization of the jaw joint, which would be a disadvantage in biting. For this reason, the horizontal component of the masseter was not dealt with in this study of the mechanics of the Pit Bull jaw.

This study of the Pit Bull's jaw involves gathering data from the skulls and jaws of Pit Bulls and other breeds of dogs. This data is then compared to determine if the Pit Bull possesses a mechanical advantage in biting as compared to other breeds of dog

Materials and Methods

I collected my data from skulls belonging to the Stockard collection, which is housed at the University of Georgia at Athens, and skulls belonging to the United States National Museum which were on loan to the Savannah River Ecology Station outside of Aiken, South Carolina. My data base consisted of forty-nine skulls, ranging from toy breeds to large breeds and including both pure breeds and F1 generation crossbreeds. Three of the skulls I examined belonged to Pit Bulls.

I took nine sets of measurements directly from the skulls and jaws thenselves (figure 2). I also took pictures of each skull and jaw examinde, and after developing these, I obtained eight more measurements and four angles from the photographs. This was done by either constructing a triangle around the jaw and measuring the line lengths and angles or by measuring the pictures themselves (figure 3). The measurements taken from the photohraphs were then converted into actual lengths by using the six inch ruler which was included in each picture as a scale.

In order to account for differences in my results due to the varying size of the breeds examined, I combined different measurements into ratios. These ratios were then graphed over the maximum jaw length to allow identification of the data points. The crossbreed ratios are shown without color, the pure breeds are represented by blue, and the Pit Bulls are represented in red. By comparing these ratios, instead of actual measurements, any structural change would be seen as an overall change in the dogs relative morphology.

RESULTS

There are two ways to improve mechanical advantage in the jaw. The first way is by increasing the amount of vertical force produced while biting. This can be done by increasing the vertical component of the temporalis or masseter.

An increase in the vertical component of the temporalis would be exhibited by a shorter, straighter coronoid process. In the graph of the area ratio (figure 4), the area of the top triangles constructed from the photographs was divided by the area of the bottom triangles. In this graph, a shorter coronoid process would be demonstrated by a lower number on the graph.

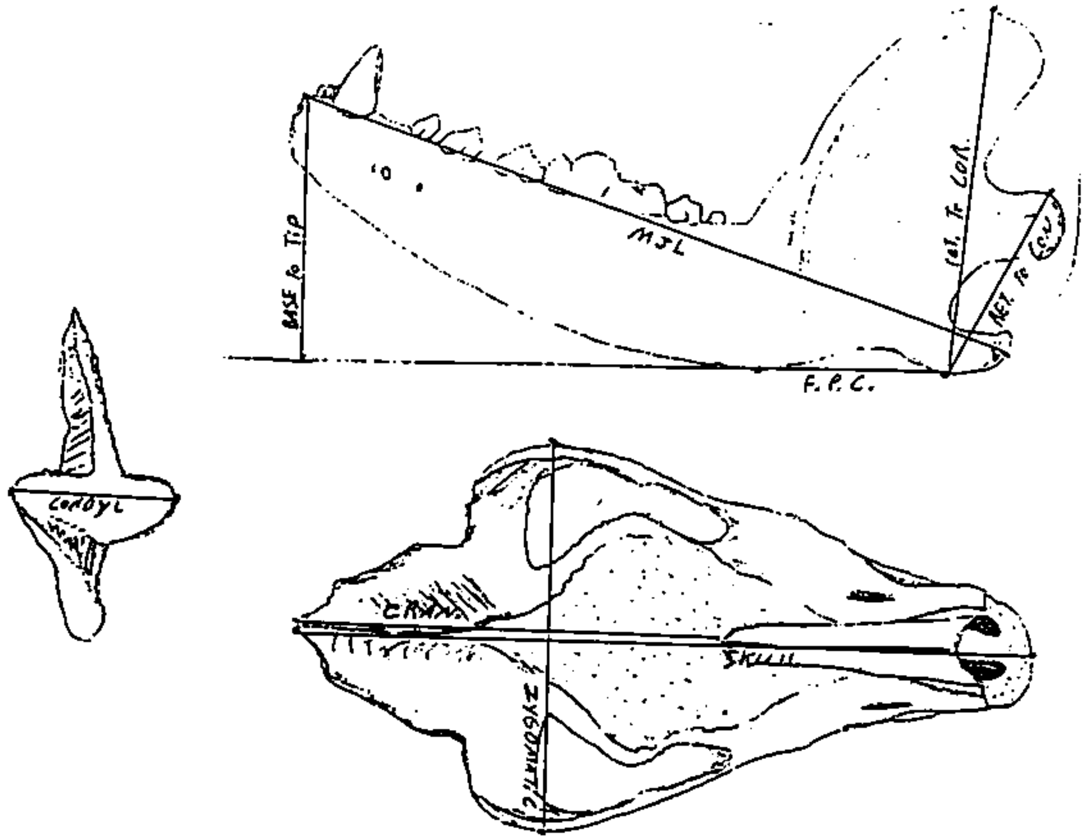


Figure 2: This figure shows the measurements taken directly from the skulls and jaws themselves. The measurements taken from the jaw are: the maximum jaw length, measured from the forward tip of the jaw to the back of the retro-articular stabilization process (retro.), the retro. to coronoid height, measured from the base of the retro. to the top of the coronoid process, the retro. to condyl height, measured from the base of the retro. to the top of the condyl, the first point of contact, measuring the distance covered by the arch in the jaw anterior to the retro., the base to tip height, measuring the distance from the extended baseline to the tip of the jaw, and the condyl width. The measurements taken from the skull are: the skull length, measured from the tip of the sagital crest to the forward tip of the skull, the cranial length, measured from the tip of the sagital crest to the point where the nasals end, and the zygomatic width, measured from the widest point on the zygomatic arches.

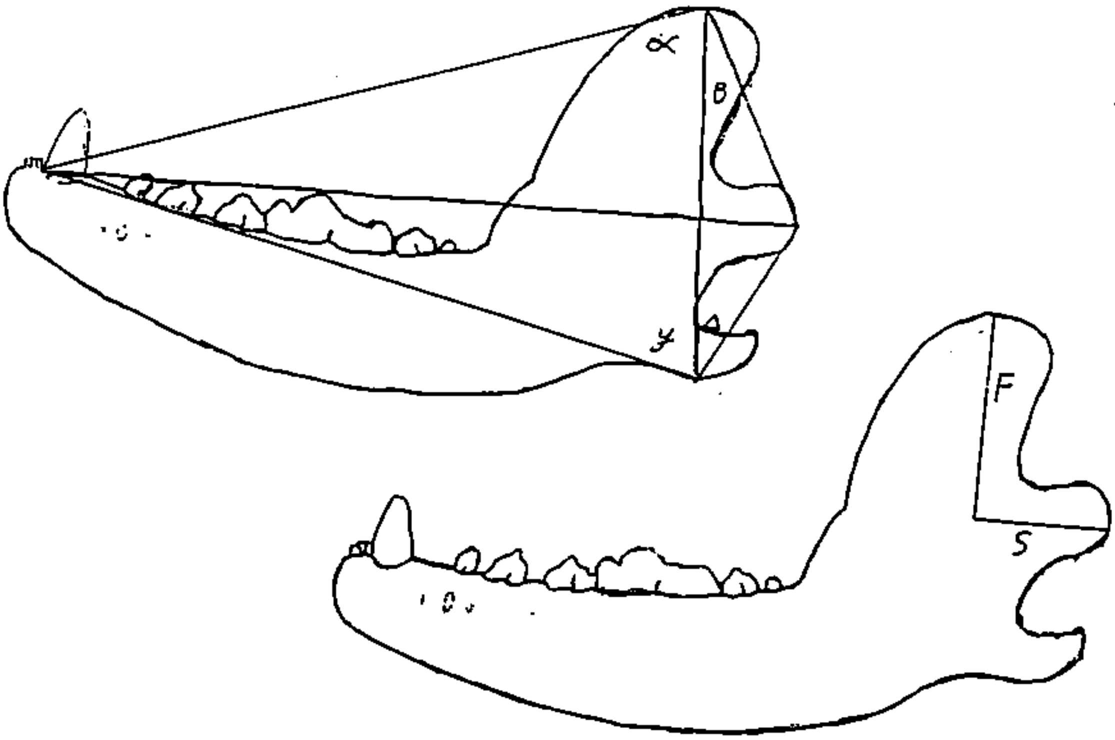


Figure 3: This figure shows the measurements which were taken from the photographs. The triangles constructed on each jaw were drawn from the base of the retro. to the front of the lower canine, to the top of the coronoid process, to the back of the condyl, and back to the base of the retro. The lines inside the triangles were then constructed between the opposite corners. From these triangles, measurements of angles alpha, beta, gama, and delta were taken. By measuring the lines constructed inside the triangles, the areas of the upper and lower triangles were calculated. The measurements of F and S were taken directly from the photographs.

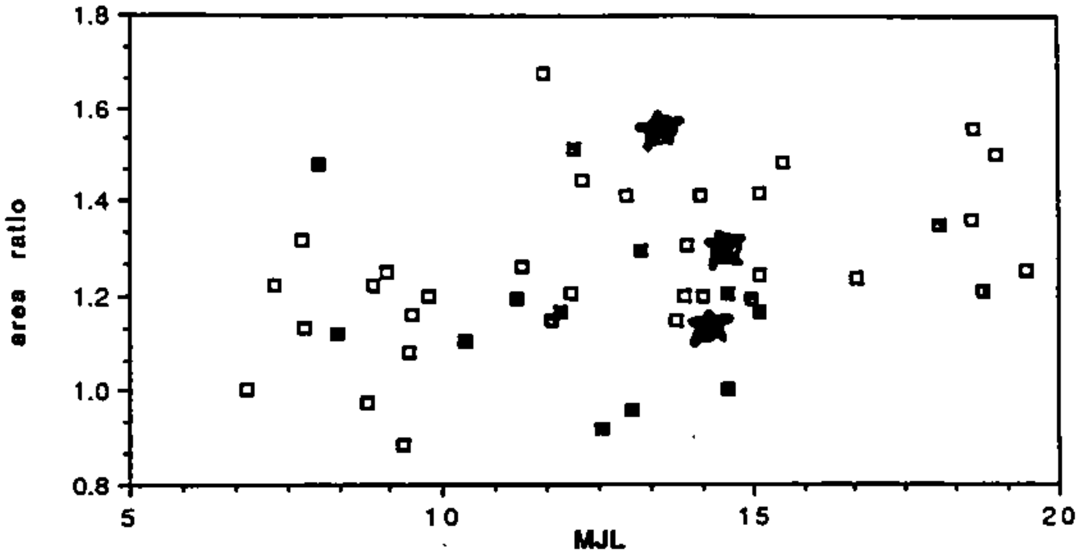


Figure 4: the graph of the area ratio of the upper and lower triangles constructed from photographs.
legend: ★ = Pit Bulls, blue = pure breeds, uncolored = cross breeds

In the graph of angle alpha (figure 5), an increase in the number on the graph indicates an increase in the angle. A larger angle would demonstrate a straighter coronoid process.

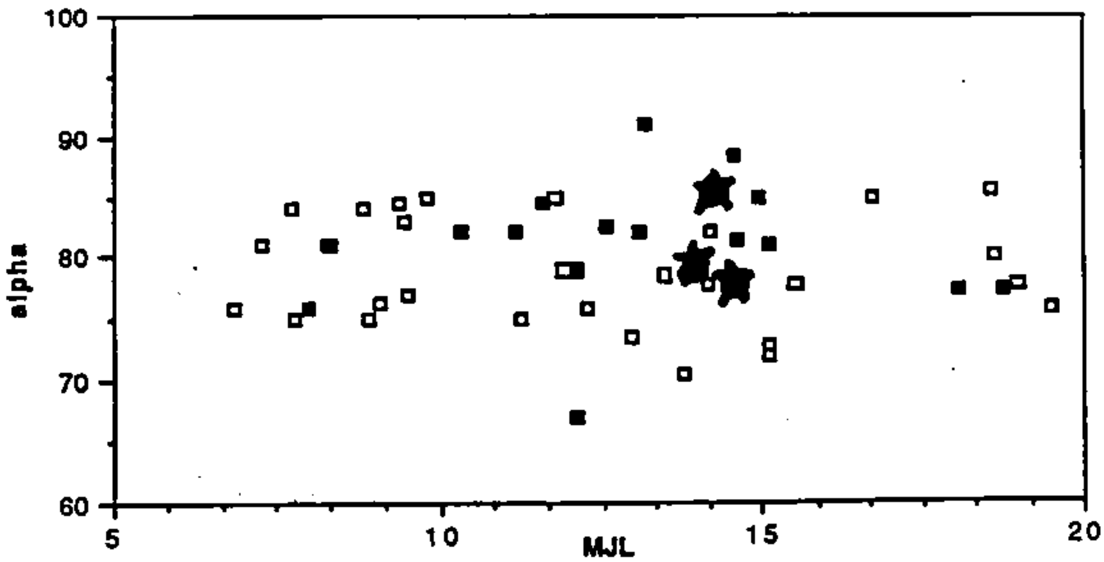


Figure 5: the graph of angle alpha constructed from photographs. (see figure 4 for legend

The graph of F/S serves a dual purpose. F is a measurement of coronoid height. A decrease in F would demonstrate a shorter coronoid process. S is the measurement of the distance between the jaw joint and the line of action of the vertical component of the temporalis. An increase in S would increase the amount of force produced by the vertical componentjust as an increase in the lever arm can increase the amount of force produced on the opposite side of a fulcrum. By combining these measurements in the ratio of F/S (figure 6), a lower number on the graph represents an increase in the vertical force of the temporalis whether it is due to F or S.

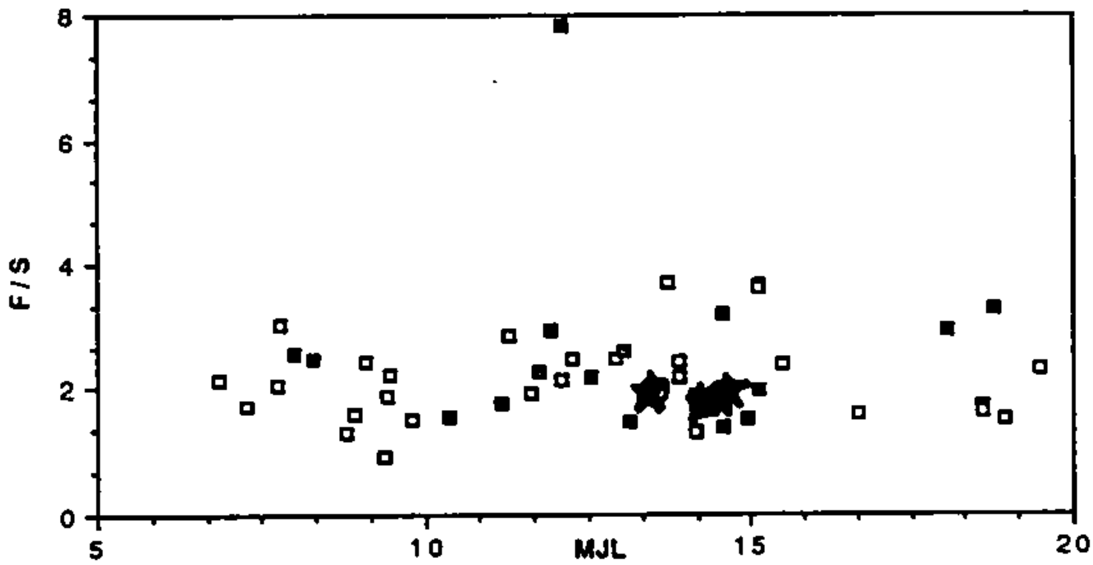


Figure 6: the graph of measurement F over measurement S constructed from photographs (see figure 4 for legend)

I had no way of analyzing an increase in the vertical component of the masseter. Instead, I examined the zygomatic arch in order to detect any change in the overall masseter size. A change in the masseter size would indicate a change in the vertical component of the masseter. The ratio of the zygomatic width over the skull length could be affected by pedimorphic tendencies. The graph of the zygomatic width/the cranial length (figure 7) is a more accurate comparison because it is a more consistent ratio. In this graph, a higher number would indicate a wider zygomatic arch relative to the cranial length.

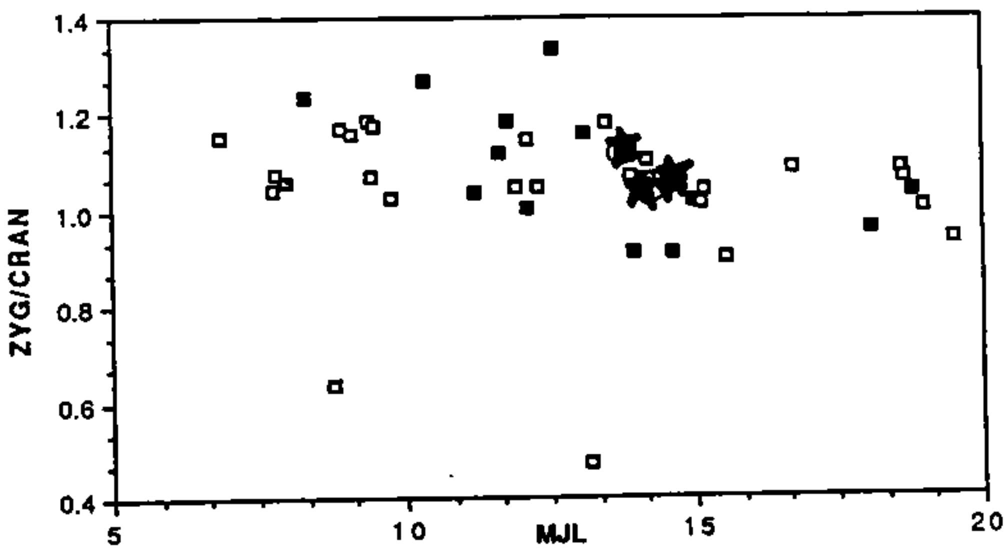


Figure 7: the graph of the zygomatic width divided by the cranial length as measured directly from the skulls. (see figure 4 for legend)

The second way mechanical advantage can be improved is by increasing the stability of the cranial mandibular jaw joint. This can be done by increasing the horizontal component of the temporalis or by increasing the stabilization provided by the retro-articular stabilization process.

An increase in the horizontal component of the temporalis is exhibited by a taller, slanted coronoid process. In the graph of the retro. to coronoid height/maximum jaw length (figure 8), a higher number on the graph indicates a taller coronoid process.

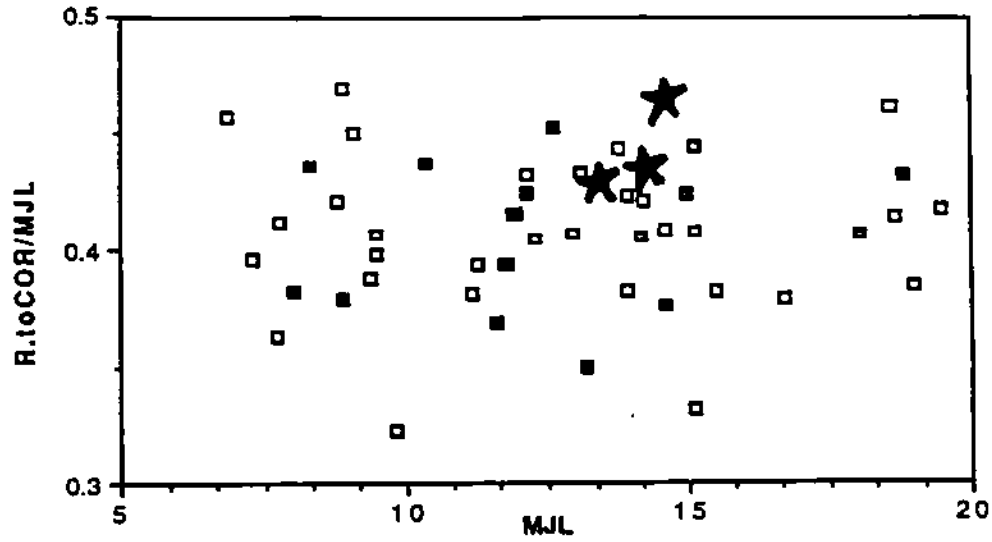


Figure 8: the graph of the retro. to coronoid height divided by the maximum jaw length as measured directly from the jaws. (see figure 4 for legend)

In the graph of angle beta (figure 9), a decrease in the number on the graph indicates a decrease in the angle. A smaller angle would indicate an increase in the slant of the coronoid process.

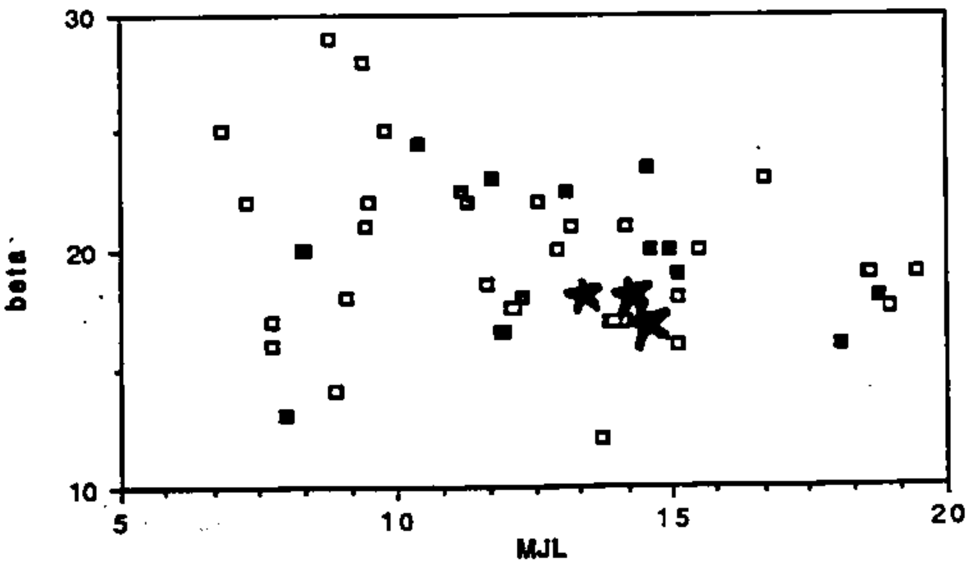


Figure 9: the graph of angle beta as constructed from the photographs. (see figure 4 for legend)

The stabilization provided by the retro-articular stabilization process is not completely understood because it is a new area in biomechanics. In order to determine if there was any change in the stabilization process,I analysed it's position with respect to the cranial mandibular jaw joint. If there is a movement in its position with respect to the jaw joint, it would indicate a change in the stabilization of the jaw provided by the stabilization process. In the graph of angle gama (figure 10), an increase in the angle would indicate a movement of the process forward with respect to the jaw joint.

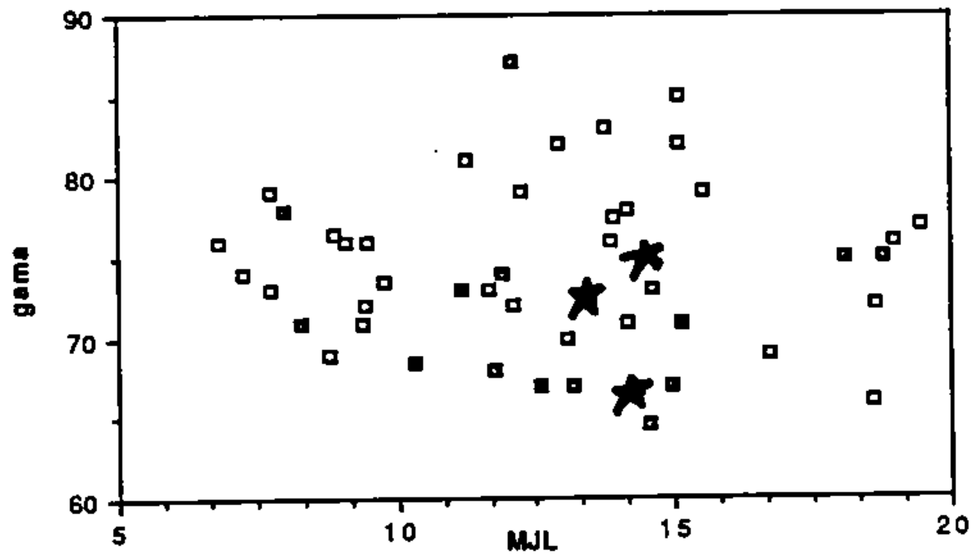


Figure 10: the graph of angle gama as constructed from the photographs. (see figure 4 for legend)

In the graph of angle delta (figure 11), a decrease in the angle would indicate a movement of the process backward with respect to the jaw joint.

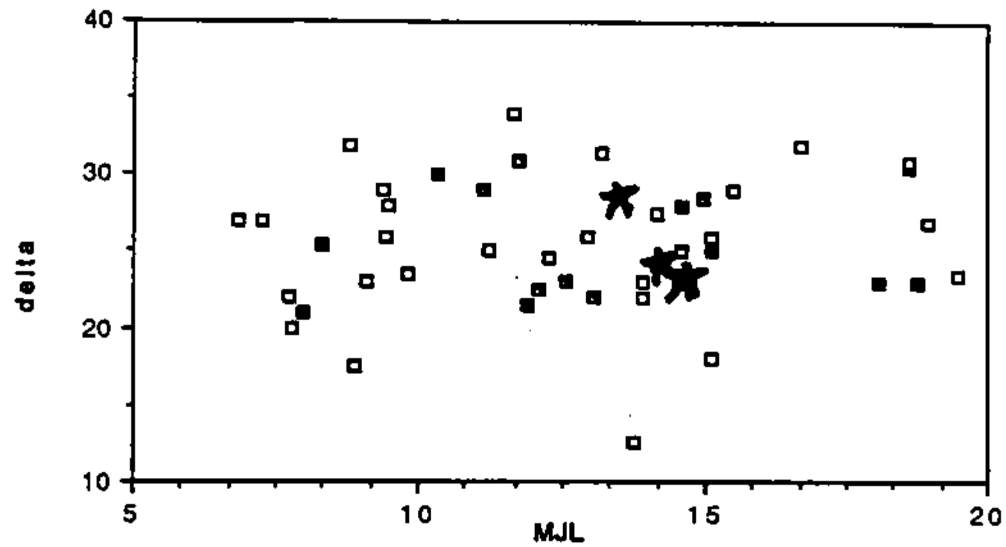


Figure 11: the graph of angle delta as constructed from the photographs. (see figure 4 for legend)

DISCUSSION and CONCLUSIONS

In order to determine if the jaws of the Pit Bull possessed a mechanical advantage compared to the jaws of other dogs, I examined the jaws and skulls for changes in the structure which would indicate an advantage was present. I first examined the structures of the coronoid process and zygomatic arch to determine if any increase in the vertical force if the jaw muscles was present.

In the graph of the area ratios (figure 4), the three Pit Bull ratios are scattered throughout the field of data. This graph is an excellent example of the diversity present in the jaws of the domestic canine, as well as the diversity present within a particular breed. This graph offers no evidence to support the theory that the Pit Bull possesses a greater vertical component of the temporalis.

In the graph of angle alpha (figure 5), the three Pit Bull data points are located well within the range of angles which were recorded. This graph shows no evidence of a greater vertical component of the temporalis due to a straighter coronoid process.

In the graph of F/S (figure 6), the three Pit Bull data points are located close to the middle of all the data points which were graphed. This graph also demonstrates no apparent advantages in the Pit Bulls coronoid structure as compared to the structures possessed by the other dogs examined. After analyzing these graphed ratios, I found no evidence to suggest a mechanical advantage in the Pit Bull's jaw due to the vertical component of the temporalis.

The graph of the zygomatic arch / cranial length (figure 7), yielded no indication of any change in the zygomatic arch. The three Pit Bull ratios are basically in the middle of the graphed data. These results indicate no change in the masseter of the Pit Bull as compared to other breeds of dogs and therefore indicate no increase in the vertical component of the masseter.

The results of my analysis of the vertical components of the temporalis and masseter found no evidence of mechanical advantage in the Pit Bull's jaw due to an increase in the vertical forces present in the jaw.

The second area in which mechanical advantage can be found is jaw stabilization. A increase in the horizontal component of the temporalis would improve the stability of the jaw because it pulls the jaw up and back against the base of the cranium while biting. In the graph of the Retro to coronoid height/ maximum jaw length (figure 8), the three Pit Bull's are located in the upper 30% of the data collected. However, this is not a significant deviation when the amount of diversity exhibited in this graph is considered. Therefore, this graph does not indicate any advantage in stability due to a taller coronoid process.

In the graph of angle beta (figure 9), the three Pit Bull data points are located near the bottom of the graph. However, they are well within the range of deviation shown in this graph and therefore demonstrait no increase in stability due to an increased slant in the coronoid process.My analysis of the horizontal component of the temporalis found no evidence to suggest that it was responsible for any increase in stability of the cranial mandibular jaw joint.

The graph of angle gama (figure 10) was used to detect any forward movement of the retro-articular stabilization process with respect to the jaw joint. The three Pit Bull data points are located well within the range of data collected. This indicates no unusual anterior positioning of the process.

In the graph of angle delta (figure 11), the Pit Bull data is located in the lower region of the graph, However, they do not significantly deviate from the rest of the data. This graph demonstrates no unusual posterior positioning of the process with respect to the jaw joint. After analyzing the position of the retro-articular stabilization process with respect to the jaw joint, I found no evidence to indicate any movement of this process and therefore no indication of any increase in stability due to it.

My analysis of the horizontal component of the temporalis and the retro-articular stabilization process produces no evidence to indicate any increase in mechanical advantage due to stabilization of the jaw joint.

The tremendous amount of diversity present in the jaws of domestic canines is obvious when the ratios of there jaw measurements are plotted. It has been observed before that the difference in the cranial morphologies of domestic dogs is as great as that between individual species of wild canids.(Wayne, 1986) It seems that this diversity is also present among members of the same breed. The three Pit Bull's examined: a mature male, a mature female, and a six month old male, all take turns holding the highest or lowest ratio among themselves depending on which ratio is graphed. With this much diversity present, it would be impossible to define the jaw dimensions of a "normal" dog. However, even though the diversity between the jaws of different dogs is wide spread, the Pit Bull's jaws do fall well within this range of diversity.

Basing my conclusions on this analysis, I have found no evidence of mechanical advantage in the jaw of the Pit Bull as compared to other breeds of domestic dogs.