

THE BALLISTICS OF “HORNUSSEN”

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“Hornussen” is an old and typical Swiss national game which has its roots in Medieval war games. Today it is becoming more and more a serious sports game using high-tech materials. The basic idea is simple: the players of one team strike a projectile one by one. The players of the other team occupy a well defined field and must try to catch the projectile before it hits the ground. A second round is played in which both teams swap their place. From the ballistics point of view, “Hornussen” implies some nice special topics and it is possible to find links to almost all ballistics disciplines.

THE GAME

“Hornussen” is some kind of war game which is played between two teams. It represents a continuous alternation between attack and defence. One team are the strikers (attackers), the other team the catchers (defenders). A team consists of 16 to 18 players. During a match both teams play each part once. At the beginning of a match the team who plays first as catcher lines up its players in a field of 180 m (about 200 yards) in length (called the “Ries”). The width increases from 8 m near the strikers to 12 m at the end of the field. The strikers take position 100 m away from the small side of the field. There they put the “Bock” which is the installation for launching the projectile, called the “Hornuss” (see Fig. 1 and also Fig. 3). The “Hornuss” is struck by the so called “Stecken” with “Träf”.



Figure 1: “Bock” with two rails, one for left-handed strikers, the other for right-handed strikers. A “Hornuss” is set at the end of one rail.

Each player of the striker team has three trials. If the “Hornuss” reaches the field the stroke is valid and the striker gets 1 point for every 10 m of range inside the field. That means a total range of 260 m amounts to 16 points for the striker. The catchers in the field try to reduce the range by intercepting the “Hornuss” using a wooden racket, which even can be thrown against it. In case that the “Hornuss” reaches the ground within the field without having been caught, the catcher team gets a fault.

Once each player of the striker team has made his strokes, both teams change place and role for a second round. The match is won by the team which has less faults than the other. In case of equal number of faults, it is the team with the higher number of points which is the winner.

“Hornussen” is a very typical Swiss game. There are only two other countries in the world which also have “Hornusser” teams. Swiss men who emigrated to South Africa founded there a “Hornusser” club and another club was founded by some German fans in South Germany. For competitions both clubs travel to Switzerland.

HISTORY

Already in the Middle Ages, games with the same basic idea as “Hornussen” were widespread in the northern regions of the Alps. The goal was always to intercept inside a defined area a flying object which had been thrown from outside. During several centuries scoring was only possible by catching the object.

The evolution of the today’s game rules began in the 17th century. The game type which was played in the region of Emmental, a region situated between the Alps and the Jura became step by step the game standard. At the end of the 19th century the game disappeared from the valleys of the Alps because of growing tourism and new sports such as e.g. skiing and climbing.

The Swiss “Hornusser”-Federation was found in 1902 and since then exist standardised rules for all clubs in Switzerland. During many years “Hornussen” was only a game for Sundays which was played by farmers. In the second half of the 20th century the game was changing more and more towards being a sport. It is easy to follow this evolution regarding the development of the used material, primarily for the “Stecken”.

The first “Stecken” were made of ash. Later on they used hickory wood. To increase the energy storage during the stroke, “Stecken” from aluminium and glass fibre were also developed. Today high-tech “Stecken” made from carbon fibres are commonly used.

BALLISTICS

Interior Ballistics

Taken in a wide sense, Interior Ballistics is the science of the acceleration of projectiles. From this point of view, the Interior Ballistics of “Hornussen” is quite extraordinary. The projectile, the “Hornuss”, is not accelerated by the continuous influence of a force but by an impulse. Thus, the energy transfer from the accelerating system to the projectile

is not given by physical work (force times path) but is controlled by the laws of collision. This principle of acceleration is not widely spread in ballistics. Only some rifle grenades with bullet catchers work at least partially with on this principle.

The "Stecken" is 2.3 to 2.6 m long. It is made of carbon fibres and is very flexible. A special wooden cylinder, called the "Träf", is attached at the end. Its task is to strike the "Hornuss" and to transmit as much kinetic energy as possible. The flexibility of the "Stecken" leads to a remarkable method for the transfer of man's force into velocity of the "Träf". Preparing the stroke, the striker winds up the "Stecken" around his body by about 450° (see Fig. 1) whereby the end approaches the striker. Then the striker turns very fast and draws the "Stecken" with him. During this motion two different acceleration principles are working: The angular acceleration of the striker and the elastic energy stored in the "Stecken" which can be supposed as a flat spiral spring.

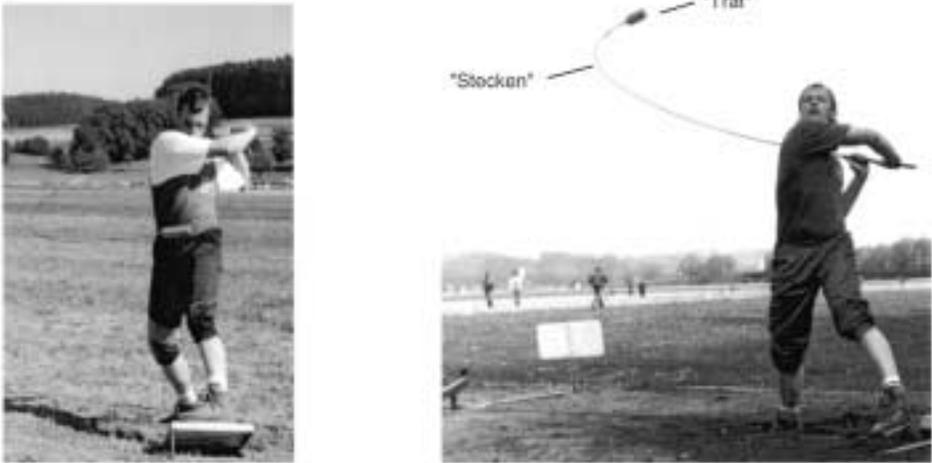


Figure 2: Left side: Position of "Stecken" and "Träf" at the begin of the stroke. Right side: Position of "Stecken" and "Träf" after a quarter turn. The total turn amounts to about 450° .

In this way it is possible to get respectable initial velocities for the "Hornuss" which amount up to 80 m/s (260 ft/s). The "Hornuss" weighs 78 g (2.75 oz) which gives an energy of 250 J (185 ft-lbf) at the begin of the flight.

Launch Dynamics

The installation for launching the "Hornuss" is called the "Bock". It has two rails, one for left-handed strikers the other for right-handed strikers. The elevation of the rail is fixed and amounts to about 25 to 30° (450 to 530 mils). The striker himself sets the "Hornuss" upright onto the end of the rail, using a small portion of clay. In this way he can vary

its height over the rail. This gives him the possibility to influence the angle of jump and the spin of the “Hornuss” which is necessary for its flight stability.

Between the “Träf” and the “Hornuss” enough friction must act in order to initiate the spin. It is very important, that the “Träf” hits the “Hornuss” below the centre of gravity. In this case the “Hornuss” obtains back spin which is a good prerequisite for the exterior ballistic behaviour. On the other hand a low hit increases the angle of jump and decreases the initial velocity. Therefore the striker must search for the optimum between initial velocity, spin rate and angle of jump. The process of the launch is shown graphically in Fig. 3.

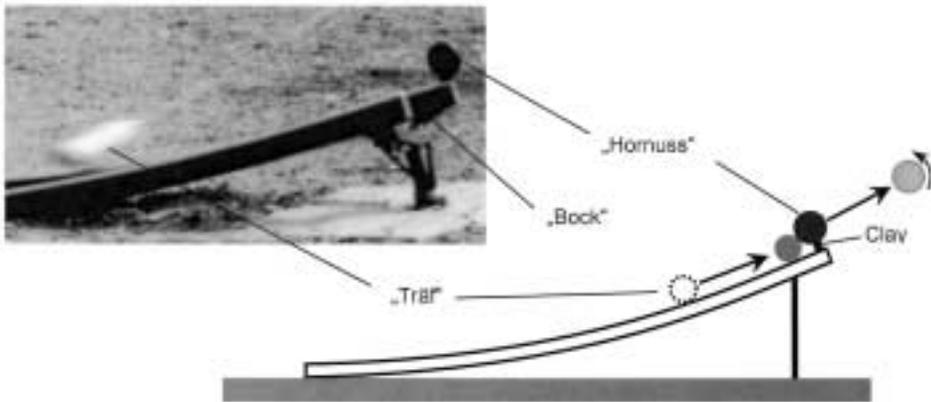


Figure 3: Launch dynamics: The “Hornuss” is set with a bit of clay at the end of the rail. During the stroke, the “Träf” glides along the rail and hits the “Hornuss” slightly below the centre. In that way the “Hornuss” gets spin and a positive angle of jump.

Exterior Ballistics and Aerodynamics

The trajectory and the range of the “Hornuss” is given not only by the initial velocity and the fixed elevation of the “Bock”, but also by the angle of jump and the transmitted spin. A good stroke provided, the back spin of the “Hornuss” induces a positive lift force due to the Magnus effect (see Fig. 4). This can substantially increase the range.

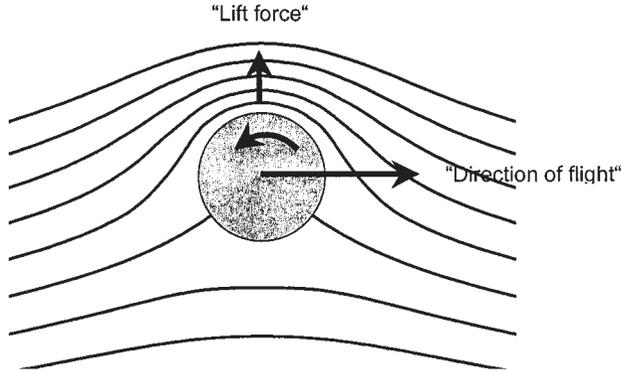


Figure 4: Lift force due to the Magnus moment can substantially increase the range of the "Hornuss".

Because of the various influences on the range, which depend on the quite individual stroke techniques between the strikers, it is difficult to calculate standard trajectories for the "Hornuss". As an example, Tab. 1 shows the ballistics data of an exemplary trajectory to the end of the "Ries".

Table 1. Ballistics data of an exemplary trajectory (v_0 : 80 m/s, elevation: 500 mils, altitude: 400 m)

Range	[m]	279.4	Change in range due to	
Vertex height	[m]	49.1	Head wind (-3 m/s)	[m] - 11.5
Time of flight	[s]	6.3	Tail wind (+3 m/s)	[m] + 11.7
Impact velocity	[m/s]	40.3	Change in altitude (+400 m)	[m] + 4.8
Impact energy	[J]	63.2	Change in initial velocity (-5 m/s)	[m] - 19.9
Cross wind deflection (3 m/s)	[m]	7.0	Change in elevation (-1°)	[m] - 3.0

Terminal Ballistics

Hard targets

The game of "Hornussen" has only few aspects related to hard target terminal ballistics. The energy density of the "Hornuss" in the field is quite low and it is easily possible to catch it with a wooden or plastic board of some cm thickness.

Wound Ballistics

At the impact in the field the “Hornuss” still has about 60 to 70 J (45 to 50 ft·lbf) and the energy density reaches values between 0.15 J/mm² (hit on soft tissue) and 0.3 J/mm² (hit on hard tissue such as bones). This is much higher than the limit for causing lacerations. Moreover the impact energy is high enough to break thinner bones as they are found on the skull (nasal bone, temple, eye socket).

Therefore, “Hornussen” is quite a risky game for the catchers and there are accidents from time to time. But they are insignificant compared with the high number of players and games. Most accidents happen with ricochets from the racket of an other player. For the player it is very difficult to estimate the trajectory of such rebounded projectiles and to react quick enough with the own racket.

The nature of the injuries caused by the “Hornuss” is very similar to the one of blunt trauma by anti riot ammunition or to the one of behind armour effects. Often there are lacerations combined with contusions, broken frontal sinus, broken nasal bone or even broken supraorbital bone. The most endangered part of the body is the eye where mostly haemorrhages and contusions are stated.

To avoid head injuries more and more catchers shield the head with a helmet with face protection. These helmets are obligatory on young players.

REFERENCE

1. Eidg. Hornusserverband (Hrsg.), “Hornusser Hand- und Lehrbuch”, 1985

GLOSSARY

“Hornuss”:	The projectile
“Ries”:	The playground
“Bock”:	Installation for launching the “Hornuss”. It has two rails, one for left-handed strikers, the other for right-handed strikers
“Stecken”:	Thin and very flexible stick of 2.3 to 2.6 m length. Tool for striking the “Hornuss”.
“Träf”:	Energy transfer module at the end of the “Stecken”, made of highly compressed wood (compression force more than 90 tons).
“Schindel”:	Tool for intercepting the “Hornuss” in the “Ries”.
“Schlagen”:	Hitting a “Hornuss” from the “Bock”.
“Abtun”:	Intercepting the “Hornuss” in the “Ries”.