ASSESSMENT OF COMBAT PERFORMANCE WITH SMALL ARMS

DAVID ROWLAND

Defence Operational Analysis Establishment
West Byfleet, Surrey

INTRODUCTION

Estimates of human performance in battle are notoriously difficult to make both because of the great many differences between the circumstances of individual battles, and the large variability between the course of battles in the same circumstances.

Extensive effort is expended in battle in attempting to degrade the performance of the other side - large parts of the effect of artillery fire, small arms and tank fire are expended in the belief that they do have some finite effect; however these degradation factors are seldom fully represented in combat models and equally cannot be assessed in peacetime trials because of difficulty in representing the danger inherent in their use.

This paper presents the result of a study into some aspects of combat degradation, mainly those relating to small arms fire in defence; the main rural combat study started by looking for one or two factors, and ended with a set of eight. The types of degradation accorded with military opinion, but the extent, especially of the combined factors, has surprised many.

The study will be presented in the following form:

a. First of all it will go through the background as to why the study was required and the reasoning behind the approach taken.

b. It will then take you through rural battles in which only rifles were used then go on to battles with only rifles and MGs.

c. It will consider the effect of artillery.

d. It will then look at the armour and anti-armour effects including obstacles.

e. It will then consider differences in making a similar comparison with urban combat.

f. Finally it will outline the approach to representing the factors in a combat model.

BACKGROUND

Over the past ten years the Field Studies Division of the Defence Operational Analysis Establishment has conducted a series of trials in which simulated direct fire combat has been represented by the use of pulsed laser weapons simulators.

These two sided trials with the capability for real time interaction allow realistic play and promote the motivation of the players. They thus provide good training for those taking part and an opportunity to collect data on appropriate types of combat to a level of resolution which would not be possible in war.

When we extended the use of this technique from armour/anti-armour combat to small arms fire there were cautions sounded on the limits of what could be represented using weapons simulators instead of live fire to represent small arms. In support of these cautions, the main evidence cited was SLA Marshal's post combat interviews with American servicemen in World War II. (Ref 1) It is appropriate to give the gist of his findings that on average only 15 men in 100 would take any active part with their weapons, and seldom above about 25% even under intense local pressure. Men with heavier weapons showed higher participation than this 15% mean, and thus the participation of riflemen tended to be lower.

We discussed the problem and rationalised that in our trials we would be representing those who did participate, and that we should, in parallel, test how relevant Marshal's data was to our data in combat modelling. However, whilst we have found a variety of responses from individuals to Marshal's work there has been no general acceptance that his findings for GIs in World War II applied to other situations - for example modern British troops.

The tactical trials themselves provided the necessary base to this analysis; they helped both in examination of historical data and in allowing the bringing together of comparative data from different sources. In particular they enable estimates to be made of the physical limitations of small arms combat in the absence of fear and, from their detail, they allow an important relationship with force ratio to be deduced and, as will be seen, tested against historical data.

RESULTS FROM TACTICAL TRIALS

The results of our close combat trials showed considerable degradation from what might have been expected from the results of live fire in range firing, so we had a reliable datum based on this live fire range situation with static targets. Comparing this range capability with defenders in our tactical trials we found several aspects of relative degradation in the latter. These resulted from overkill and from less accurate fire due partly to target movement and partly to a slower rate of fire in the tactical situation - especially for rifles. Putting these factors together we obtained total degradations of the order of ten times between range and tactical trials although larger for rifles, and smaller for machine guns.

The degradation in rate of fire, which was most marked with few targets available to fire at, was also studied. As the graph in Fig 1 takes the same form as those in figs 3 and 4, let me first explain the axes. The number of targets available is expressed as force ratio on the horizontal axis. The effect of rate of fire as attack casualties per defender (over the whole battle is on the vertical axis. Each axis on these graphs is plotted to a logarithmic scale as it allows a wide range of values to be represented, and also allows the expected relationship to be approximated by a straight line.

This graph (Fig 1) summarising casualties inflicted during tactical trials shows the variation of attack casualties per defence weapon for rifles and machine guns. At a 4:1 force ratio the casualties are approximately double those at 1:1 force ratio. Another significant finding from all our simulated combat trials is the large variation in contributions, between individuals even among those who do participate. Turning to real combat data, how could we compare the fragmentary and superficial data from this source with our detailed trials data?

ESTIMATES FROM HISTORICAL DATA

Given the nature of recorded combat data the comparison could only be at a fairly high level of aggregation between overall totals of attack casualties in an attempted assault, without knowing at which stage they occurred or what caused them, compared with the quantity of defence weapons or men.

In comparing these figures we were also faced with the possible variations of degradation between weapons - Marshal data indicated greater non-participation by riflemen than by heavy weapon crews, so we could not ignore that possible difference, nor could we ignore the effects of defence or attack indirect fire.

Fig 2 is a diagram of weapon usage through time; it indicates the way into the problem. It may be seen that in the 1860s rifles replaced muskets, and were for the next 50 years the main small arms in use; although machine guns were used in the Boer War, their major use started during World War I. At about the same time artillery fire changed from direct to observed indirect fire, and tanks came into use as a means of reducing the defence's direct fire advantage. Anti-tank guns, other than simple expedients, dated from World War II.

By considering battles before 1914 we were able to confine our analysis to examining the degradation to rifle fire. We can then consider the other weapon effects by selecting battles in which only some were present, working forward to include eventually all those battles for which data are available.

HISTORICAL DATA ON RIFLE AND M.G. EFFECTIVENESS IN BATTLE

Thus it was decided to attempt to obtain first an estimate of rifle effectiveness by considering battles before machine guns and indirect fire became significant; sets from battles in the Boer and US Civil Wars were used.

There was however tremendous scatter in the combat results; eventually - remembering the sensitivity of trials firing rate to number of targets, I examined the results for the effect of force ratio, and these showed a significant relationship which allowed much of the apparent scatter to be explained. Examination of separate results by war and by success of attack allowed the data extracted from these two wars to be pooled and used for analysis together. Results are shown in Fig 3. As with the trials results, these are plotted as attack casualties/defender against force ratio (a measure of target availability).

Other battles were also examined for evidence of any differences from the trend - the Franco-Prussian War, Rorkes Drift in the Zulu War, and notably three battles in World War I with British rifle defence (Landrecies, Mons, Neuve Chappelle) all follow the trend closely.

Altogether a total of 47 battles in which rifles were the main defensive weapon provided a good estimate of the relationship between attack casualties/defender and force ratio - with 65% of the variation explained by force ratio, and the remaining 35% giving a spread similar to that expected from comparison between similar battles under trial conditions.

. However the order of effectiveness for rifles in defence was very different from the combat trials results. Fig 3 also shows these simulated battle results, reduced to the same form and scale and assuming that our highest trial level of combat, with up to a company visible to a defender, is a representative slice of the generally larger battles from historical data. The similarity in trend of casualties with force ratio is at once evident from the gradients, but with battle casualties/rifleman about one tenth those attributable on trials, possibly down to one eighth at 3:1 force ratio. In absolute value, attack casualties inflicted by each defending rifleman present in a real battle were about 0.5 at 3:1 force ratio falling to the 0.25 at unity force ratio.

This 10:1 ratio between the trials results and the results of the wars studied, is consistent with Marshal's participation factor of at most 15% for riflemen (which implies a degradation factor of at least 7:1 (Ref 1). The results of trials and analysis of past wars studied are together consistent in that the slopes (in fig 3) are similar and Marshal's findings could explain the difference in kill ratio for rifles; but what about heavy weapons which Marshal found less degraded?

In general, defensive forces with machine guns also deployed mortars. In order to make any examination of these heavy weapons, it was therefore necessary to separate the effectiveness of MGs in causing casualties from mortar effectiveness (Ref 2). With this defence indirect fire relationship and the estimated effectiveness of defence rifle fire, it was now possible to use attack casualty data, deduct casualties attributable to defence rifles and then apportion those remaining between "equivalent machine guns".

Figure 4 indicates that MGs in combat were about 15-25% as effective as on interactive combat trials, a degradation factor of about 1 in 5, and notably better than for rifles; this again is generally consistent with Marshal's findings.

When I now plot the results of World War II battles (except the D-Day beaches) as attack casualties/defence m.g. against attack AFV/defence mg there is a significant relationship (see fig 8). While the points do at first sight appear scattered, the correlation coefficient of 0.8 is fairly high indicating 65% of the variation is explained by the relationship. Moreover the best fit line through the points is robust to the inclusion of the extreme point (for Ops Veritable) which might be thought to have been driving it; the broken line represents the relationship if Op VERITABLE is excluded. Fig 9 compares the D-Day beaches and other World War II battles, both relationships show remarkably similar gradients.

There still remained another discrepancy however, whilst these results showed a marked trend to suppression of the defence it is not very significant at about 2 tanks/defending machine gun. Consider by contrast the effective suppression of the Australian defences at Tobruk on 1st May 1941. Typical actions described in the Australian Official History recounted the attack on each half platoon post by two German tanks. These bombarded the posts, then a few infantry dismounted under cover of tank fire and dropped grenades into the weapon pits forcing the defenders to surrender.

Here near total suppression was achieved with two tanks per machine gun, and it was suppression of resolute defenders as earlier battles had shown. The Australian problem was lack of anti-tank guns, so how would the presence of defence anti-tank fire effect attacking tanks? Either simple imagination or a little further analysis of history suggests the answer - defensive anti-tank fire dilutes the attacking tanks' attention to defence small arms since a share of this attention is given to detecting and engaging the immediate threat to the tanks themselves.

A closer examination of battles with attack tanks but with no effective anti-tank fire is possible by an examination of World War I battles in which tanks were used. These included the major battles such as Cambrai and Amiens, in which the use of tanks was remarkably successful and smaller local actions for which data were available. When plotted in the same way as before we obtain a similar curve, Fig 10 - but here there is a marked degradation (by a factor of 10) at about 2 tanks/m.g. as noted incidentally for Tobruk, instead of at 8 tanks/mg as for most World War II battles - as shown to this scale on the two broken line curves - brought forward from previous Figures. This means that the tanks in WWI caused a generally greater degradation, for a given number, than tanks in World War II.

The hypothesis of dilution of attention suggests a means of combining the two sets of data - to equate the attention given to an anti-tank gun to that given to say 'x' machine guns - 'x' will be expected to be bigger for more powerful guns but as a first step we will consider a 'typical' World War II anti-tank gun, since to do more would strain the limits of available data. A value of x was estimated from the extreme of the World War II battles - Ops VERITABLE and CLIPPER - the value obtained was used in all those battles with anti-tank weapons to calculate a total of equivalent defence mg including the attention due to representative machine guns.

Effects of Attack Artillery

Further examination of the World War I and II battles showed many whose rifle and machine gun effectiveness was even lower than that described above. It was possible to associate some of these with the after effects of preparatory attack artillery bombardment. Again some World War II operational research studies (unpublished) had examined sets of battles and produced estimates of artillery bombardment duration (from fire plans) and density from crater count.

Each set was characterised by a different duration of bombardment - several minutes for D-Day, several hours for Ops Veritable and Clipper and days for the Pacific Island assaults. Bearing in mind their relative durations, the relative slopes of these lines form a consistent pattern - for a given total weight of bombardment the shortest/sharpest provides the greatest degradation. Thus, for example, the Normandy landings show the greatest degradation for a given weight of bombardment, and the bombardment was the shortest of the three in duration.

Fig 7 shows the relationship between the density and duration of bombardment required to achieve a given level of degradation is linear when plotted on a log-log basis. Thus, for example, to achieve 90% degradation a density of 0.4 lb. HE/square yard over a duration of one hour is as effectie as a density of 4 lb.HE/square yard in 100 hours. It should be noted, here, that 90% degradation imples a further factor of 10, on the effectiveness in figs 3 and 4.

From these curves a relationship for degradation due to artillery can be devised in terms of density and duration - thus results of these and other individual battles can be corrected to zero artillery bombardment - increasing the actual casualties to a notional figure to be expected had there been no preparatory bombardment.

Effects of Attack AFV

Even after applying the correction for preparatory artillery bombardment there remained several battles in which defence weapon effectiveness was substantially lower than the figures I have quoted.

Qualitative comments on the effectiveness of attack AFVs in suppressing defence small arms fire are not rare; however, although this was the original raison d'etre of the tank in World War I and great effort and ingenuity were expended to get them ashore on D-Day, there has apparently been no attempt at assessing their effect in the role of infantry suppression.

Collecting together the available casualty data, deducting casualties due to rifles, correcting for defence indirect fire and attack preparatory bombardment, I then attempted an examination against a measure of tank density. In order to bring together different size battles the tank density was represented as a type of force ratio - as attack tanks per defence machine gun.

Plotting World War II battles as tanks per equivalent defence mg when anti-tank weapons are included in the equivalence, in Fig 11, shows the results of the two wars merge together into one general relationship. World War I points are indicated by circles showing that results from the two wars are consistent after the correction based on one World War II set of battles.

Turning from attack AFV and defence anti-tank, a completely different factor can now be seen to be associated with a part of the remaining scatter in the results - the difference between battles in which the defence have prepared positions and obstacles - open points, and those in which they have not - shown by solid points. If these points are divided on this simple description, two nearly parallel lines are obtained, the lower without preparation - the upper with; the ratio of the two providing an estimate of the effect of this type of preparation as being a 1.65 factor in defence effectiveness. This accounts for the differences in absolute levels in Fig 9, 10 and 11.

Final estimates of Machine Gun Effectiveness in Battle including the Effects of Armour.

If all results are now corrected to the zero fortification case, using this 1.65 factor, we find these sets of points overlayed as in Fig 12. While there is still some scatter, the line shows a correlation coefficient of 0.94 - which means that nearly 90% of the variation between battles is explained by the factors we have isolated. The remaining variation is equivalent to that between battles on our interactive trials indicating that we can reduce it little further. The intercept of Fig 12 at zero AFV and zero fortification indicates 2 casualties /m.g. at 1:1 force ratio, close to that derived in the preliminary analysis in Fig 4, and indicating a degradation factor of 6 on tactical trials.

Thus the militarily believed value of AFVs in the attack is confirmed by three independent sets of results, which can themselves be related by taking account of defence anti-tank weapons and obstacles. While the suppressive effect of tanks on infantry in defence has been lost sight of in recent analyses which have concentrated on the armoured battle, it can now be represented in combat simulation, as can the effect of defence anti-tank weapons in attack infantry casualties.

URBAN COMBAT

As we planned the urban trials we were aware of these live fire differences but had no way of representing them without militarily unacceptable limitations to the defenders. Thus our approach was the same as that used in our analysis of rural battles, to conduct trials followed by historical analyses. We also found it necessary to carry out two separate trial's simulating

a. Within house combat

b. between house combat using rules developed from a.

The preliminary urban trials representing house clearing operations indicated a benefit to the attack from experience in the role. Fig 13 illustrates the effect showing a 50% reduction in exchange ratio with experience.

When we came to the main external trial we were concerned to test whether there could be a similar benefit in the company assault to clear an urban area. (Here I must note that although we brought forward rules for house clearance casualties from the earlier trials we did not bring forward any experience effects so that any such effects detailed in this trial could subsequently be added to those obtained from the earlier house clearance trials.)

In designing our main external trial we were able to include a simple test for this effect by interchanging attack company and defence platoon at different times, partway through the trials (Fig 14). Examining these results we found, on the basis of attack casualties/defender present, no detectable benefit with defence experience. However there was a slight but non significant benefit to the attack with experience.

The effect of attack experience was more marked if considered against exchange ratio, that is attack casualties divided by defence casualties. In the conditions of trials battles this measure is a better indication of defenders included in battle - because defenders tended to stay and fight until killed, and also because trial battles were also terminated at arbitrary end points.

A plot of these exchange ratios against experience is shown in Fig 15, for three companies in several interactive battles when using VP attack tactics. Despite the scatter there is a significant trend to reduced exchange ratio with experience. This negative exponential fit indicates a halving in ratio after 10 battles. (A linear regression shows a similar correlation coefficient, but does not represent the expected form of learning curve so well).

Turning now to a comparison of historical and trials data, the first area for comparison is that of defence casualties. As mentioned earlier, on trials battles, with no more real threat than simulators, most defenders fought to the end - that is until 'killed' - given that there were sufficient attackers to achieve this. In real, live fire, battles a very different picture was apparent (Fig 16); unless they could withdraw, then twice as many defenders surrendered, or surrendered wounded, as were killed. So given the possibility of defence withdrawal the outcome would typically be as shown here. These ratios were not sensitive to attack AFV density or force ratio - or to anything except to being totally surrounded.

As a result of our examination of attack casualties in real European battles for comparison with the earlier, rural trials data available, it was obviously worth checking for the effect of force ratio and attack tanks. We divided the battles into groups by tank density, (Fig 17) which would be expected to offset these curves. The main groups are shown here, plotting attack casualties/defender against infantry force ratio. Each shows a significant trend with force ratio, the gradient of which, as the graphs are plotted on logarithmic axes corresponds to the index of force ratio. These independent sets yield very similar powers of about 0.50, lower than the value for open country battles (0.685 Ref 2) indicating that attack casualties are less affected by force ratio in urban attacks. The pattern of offset or vertical shift of these four curves with tank density is broadly as expected; this effect is considered below.

This relationship with force ratio was used to reduce all battles to unity force ratio to test for the effects of AFV density, now using all 73 available battles. (Fig 18). In this graph, as in the equivalent open country, "casualties/defender" is plotted against "attack tanks/equivalent defence machine gun", taking the same attack tank dilution factor as derived in the rural study, for defence anti-tank guns. These results also show a significant suppressive effect from the use of attack tanks. The general trend can be compared with that from rural battles; it is the same order of effect, a result which has surprised many.

The comparison also allows the absolute casualty values of rural and urban defence to be compared - urban being 60% less effective with no attack tanks. Having explored these effects we can now attempt a comparison of attack casualties/defender between trials and live urban battles at an equivalent force ratio and at zero tank suppression. This comparison yields a live battle figure of 0.51 cas/defender at trial force ratio (of approx 3:1)to set against trial figures of 2 to 3.8:1 ranging with experience - differing by a factor of between 3.7 and 7.2:1 respectively, to be compared to the 7.2:1 to be expected in rural combat (for a machine gun-rifle mix.)

Study of the regimental histories of the units involved in urban attacks shows that few battalions made many, that they were interspersed with rural combat and that as the units took significant casualties they are issued with replacements which would dilute the value of experience. Making allowance for these factors it is estimated that the mean equivalent starting experience was approx 3 to 4 KINGS RIDE battles corresponding to a 3.0:1 trial exchange ratio. This differs by a factor of 6 from the live battles, in close agreement with the rural figure of 7.2 from an independent set of data.

The supplementary question which comes to mind is, if this learning is significant and applies to real combat, can it be derived from that data too?

The sample of data included had been extended after a pilot study to those sets where battalions have fought urban battles without significant replacement, and could be traced through war diary data.

These are shown in Fig 19, a total of 42 battles (of the 73 live battles used previously). Each battalion with sufficient experience to give a comparison shows a trend to benefit from experience, and the combined set shows a significant trend. For comparison if we now bring forward the previous trials curve for experience in Fig 20, the results are confirmatory both in order and in effect of experience, a very robust confirmation in view of the independent derivation of the two sets.

Another set of historical data also supports the effect of attack experience. The set for 24 village and urban battles in Burma when analysed in the same way showed a similar effect. Fig 20 illustrates this, with a very similar order of attack casualties and a similar but lesser effect of experience. The notable difference for this set (not shown) was the insensitivity to attack AFV density.

THE REPRESENTATION OF DEGRADATION AND SUPPRESSION IN MODELLING

Each of the degradations discussed here, shows factors of up to an order of difference in capability. Although the broad effect of each was now quantified and available to modify our detailed trials data, we had to decide how to do this, bearing in mind the inevitable lack of lower level detail inevitable from historical data sources.

A third source was also available on defence suppression (Refs 3,4): this constituting a detailed study of the relative effects of weapon type, size, rates of fire and accuracy - but with the safety limitations necessary in such experiments removing the absolute values of each.

The approach towards investigating the combined use of historical analysis and trials data in operational analysis was first to design and test a model of the detailed interactions recorded in the trials situation using weapon simulators. This constituted a Phase I model, with personnel subject only to physical limitations and with simulated weapons calibrated to the performance of the real weapons measured in clinical field trials. This Phase I model was then successively elaborated by including other factors assessed from the other trials and historical data sources to include: live fire, suppression, close quarter battle and surrender, and in Phase 2 represented all physical and psychological limits which had been observed.

The process is shown diagrammatically in Fig 21. This also indicates that the model output was tested at appropriate stages - initially against trials scenarios, later against generalised results from historical data, and finally against two real battles for which the samples of replicated runs could be compared against similar sets of assaults within larger battles.

The model construction was conducted under contract by Hunting Engineering Ltd (HEL) hence the model name HELICCS (HEL Infantry Close Combat Simulation).

In Phase I a low level high resolution stochastic model of company platoon combat was set up. This specifically represented the factors shown in Fig 22, derived from analyses of the reconstructed battles of our rural trials (Ex KINGS RIDE I and II.) Following calibration to these, the comparison between a set of 12 replicated platoon attacks (in KINGS RIDE I) and the model is shown in Fig 23. A comparison with the individual scenarios of company attacks in (KINGS RIDE II) is shown in Fig 24.

The stochastic model was elaborated in Phase II to include the factors shown in Fig 25:

a,. b. Data for suppression were derived from historical data for absolute value, US trials for relative effects.

c. The degradation effect of live fire was based on historical analysis.

e. The effect of defence artillery was based on modelling the effects of individual rounds and calibrating the overall effect against historical data.

f. The effects of infantry anti-tank weapons were derived from trials (Ex KINGS RIDE IIA and IIB.)

g. The continuation to the overrun or close quarter battle was based on specific very short range trials at DOAE, (Ex KINGS RIDE IIC), modified by historical data on degradation.

h. Probabilities of withdrawal and surrender were based on analyses of historical data.

A comparison of the effects of attack AFV suppression as modelled and the broad results from historical analysis is shown in Fig 26.

Final comparisons were made with two sets of battle in which separate results from broadly similar attacks were available, to test the variability of model output against that between real combat situations. The two chosen were:

a. The British attack on the first day of the Somme (July 1916) in which a purely infantry force, with 84 battalions attacking suffered enormous casualties. (Fig 27)

b. The British attacks on the Normandy beaches (6 June 1944) when massive AFV support played a part in securing light attack casualties. the data are for six battalion attacks in two company waves.(Fig 28)

The comparisons indicate good agreement in both means and in the variability of the casualties between local 'replications'.

Having now consolidated our separate sources of data into a model which represented company-platoon combat in considerable detail - and which could be a useful investigation tool, we had to make the output usable for higher level models. This, Phase 3 of the development used the HELICCS model to generate distributions for a simplified Model of Infantry Close Combat (SMICC). This was developed as:

a. a stochastic model producing win/lose probabilities and expected casualties.

b. a model capable of functioning as a subroutine to a more general model of combat including armour/anti-armour.

This development is now complete for open country battles, we are examining the possibility of its extension both to woods and to parts of the urban battle.

<u>References</u>

1. Marshall S L A 1946
   Men Against Fire
   Infantry Journal and Morrow NY

2. Rowland D 1986
   Assessments of Combat Degradation
   RUSI 131 No 2.

3. Anon 1976
   SASE Small Arms Suppression Evaluation
   USA CDEC

4. Anon 1977-78
   SUPEX: Suppression Experiment
   USA CDEC

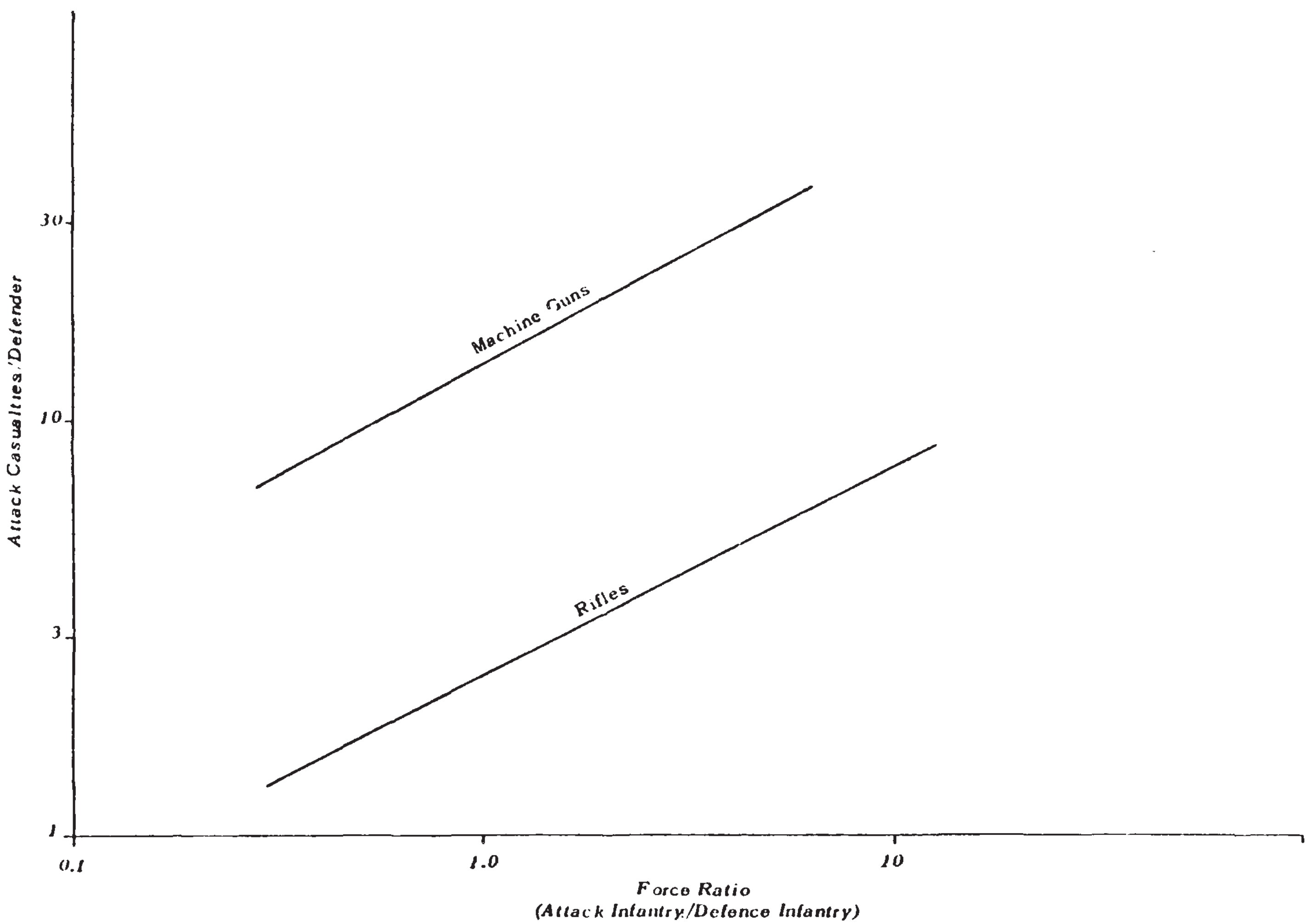


FIG 1. VARIATION OF ATTACK CASUALTIES/DEFENCE WEAPON WITH FORCE RATIO FROM INTERATIVE TRIALS DATA

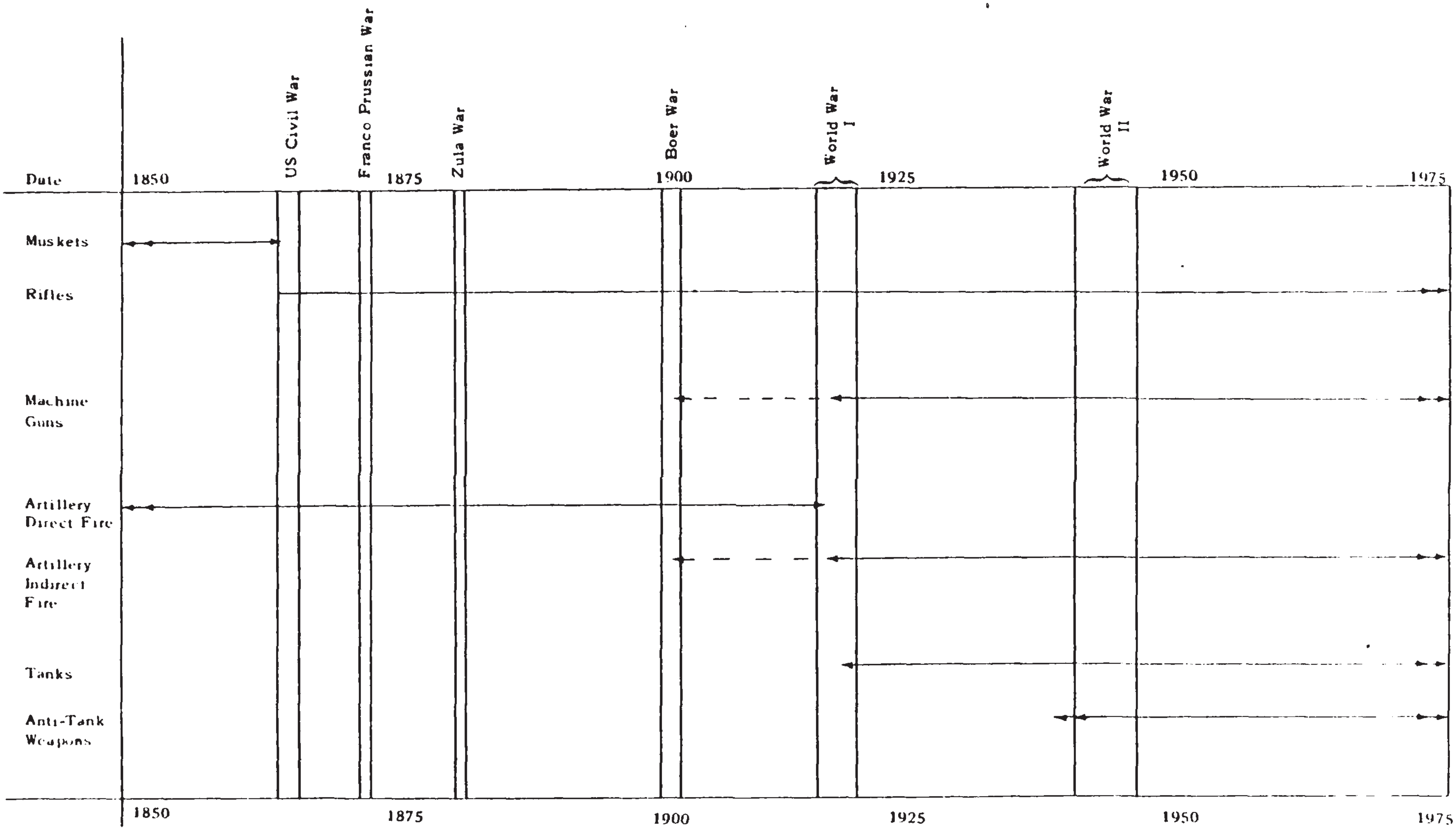


FIG 2. WEAPONS IN USE IN SPECIFIC CONFLICTS

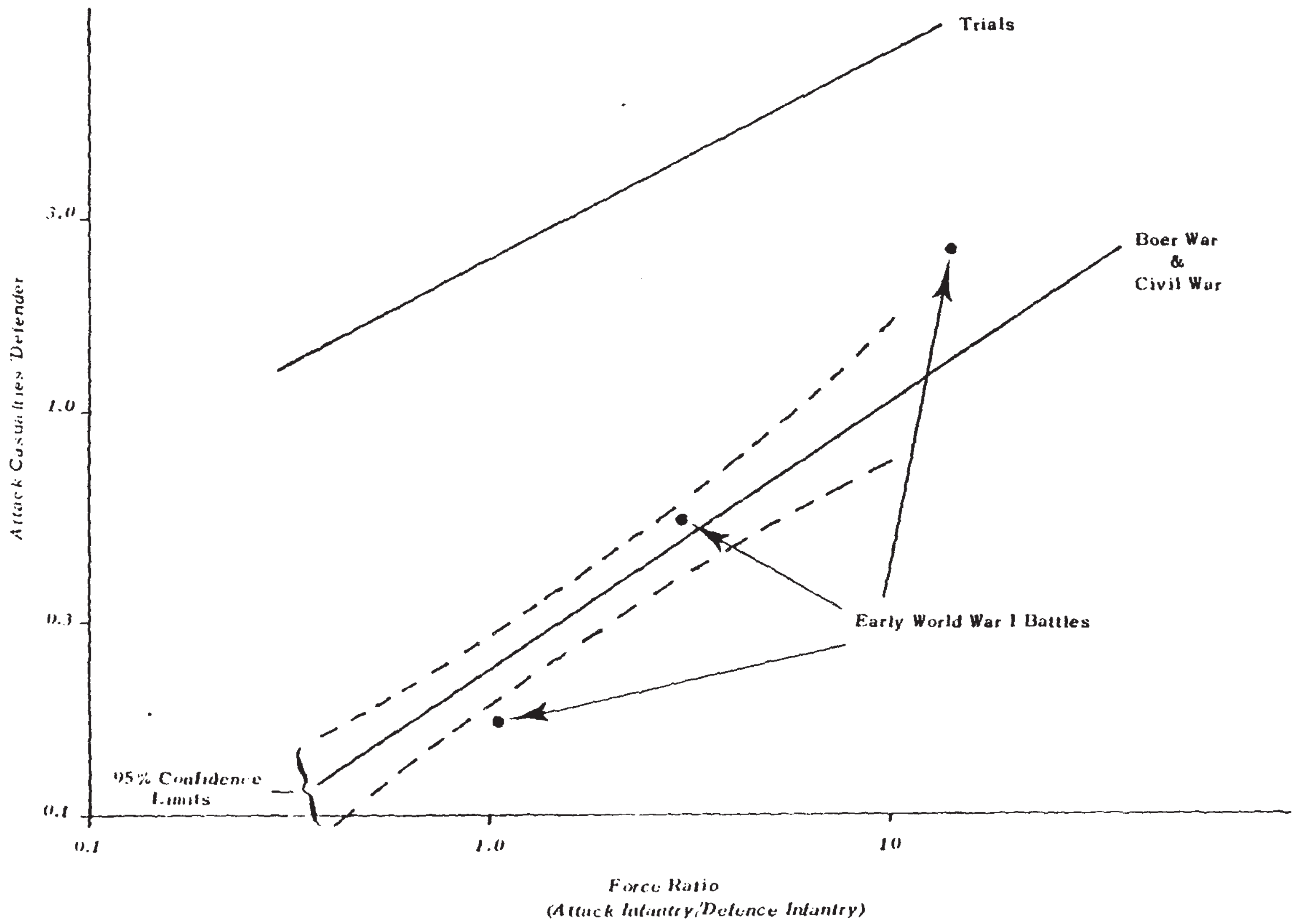


FIG 3. COMPARISON OF RIFLE CASUALTY ESTIMATES FROM TRIALS DATA, BOER WAR & CIVIL WAR (POOLED) AND WORLD WAR I

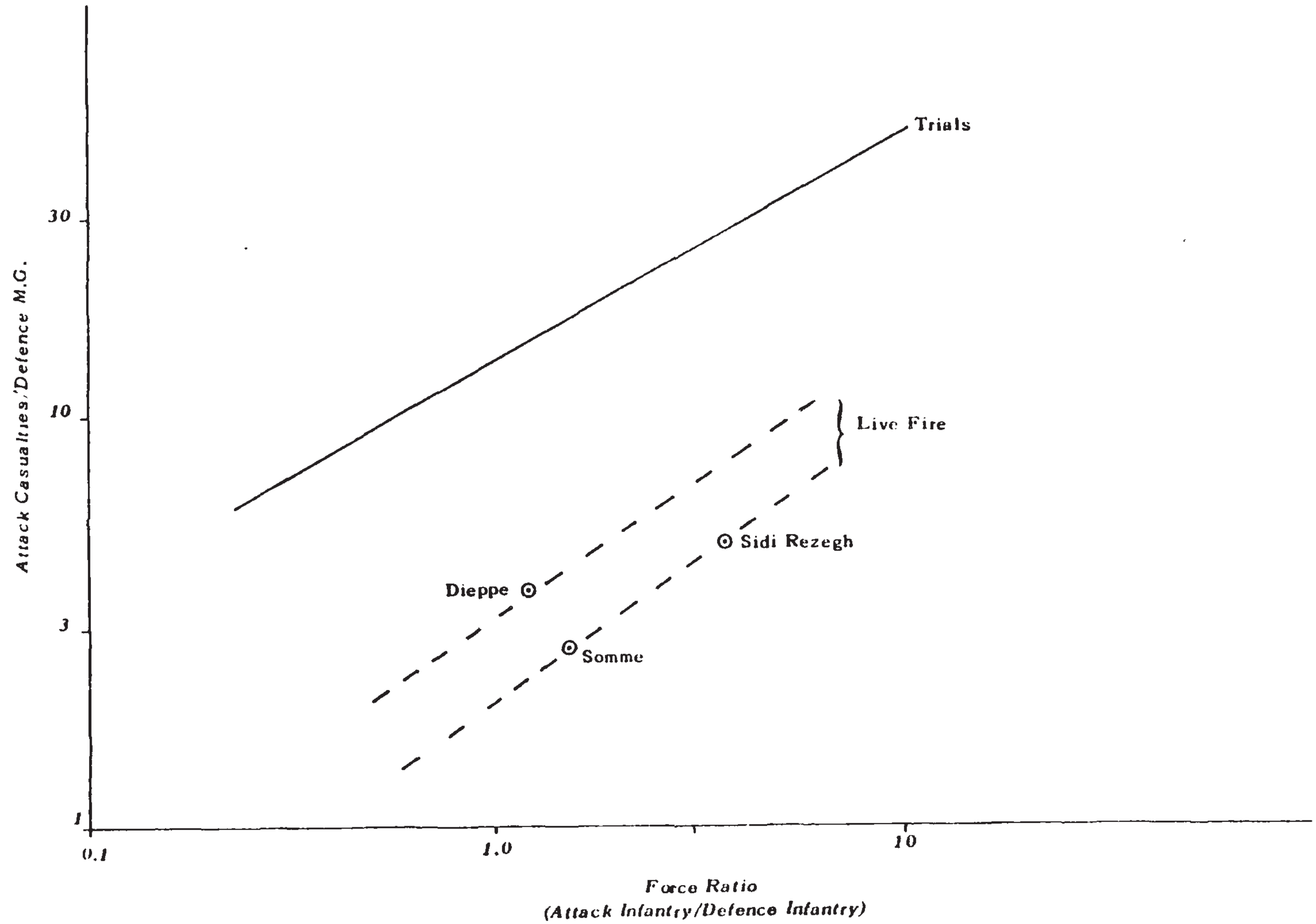


FIG 4. COMPARISON OF MG CASUALTY ESTIMATES FROM TRIALS AND COMBAT DATA

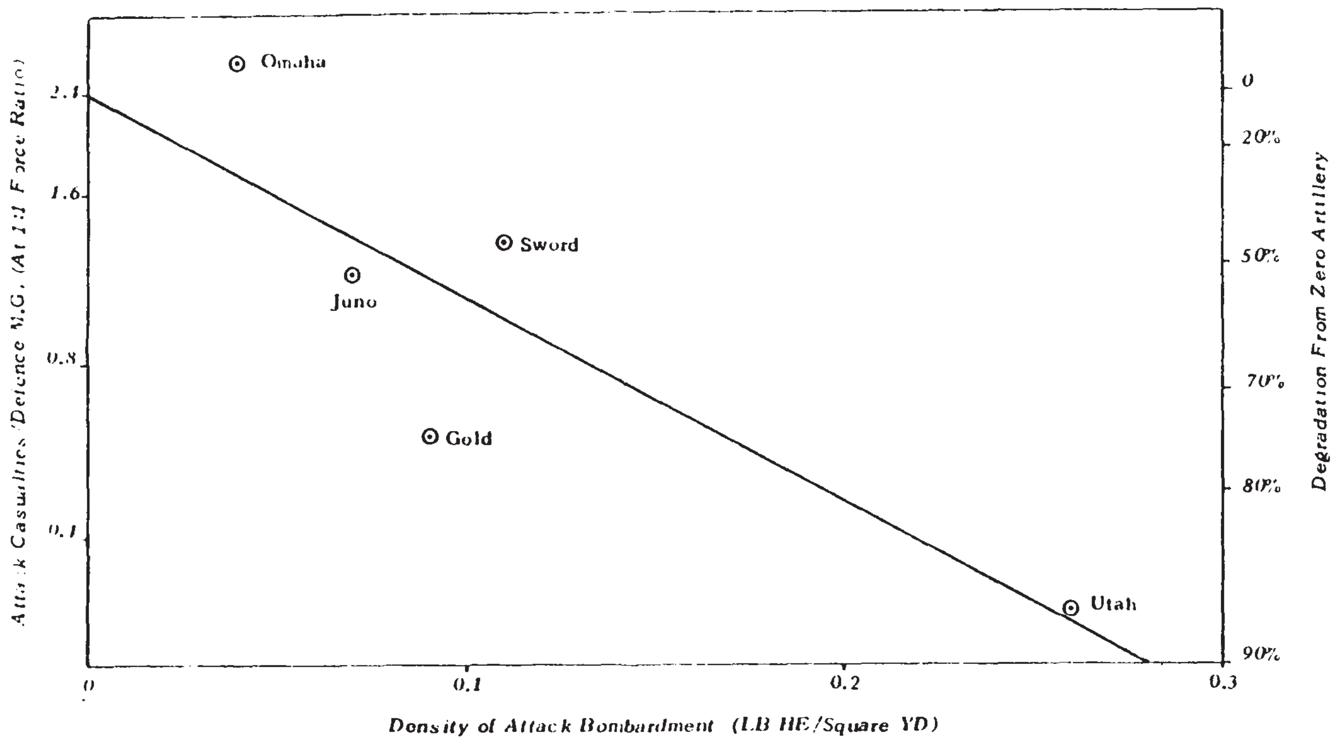


FIG 5. EFFECT OF DENSITY OF PREPARATORY ATTACK BOMBARDMENT ON ATTACK CASUALTIES/DEFENDER, HENCE DEFENCE DEGRADATION

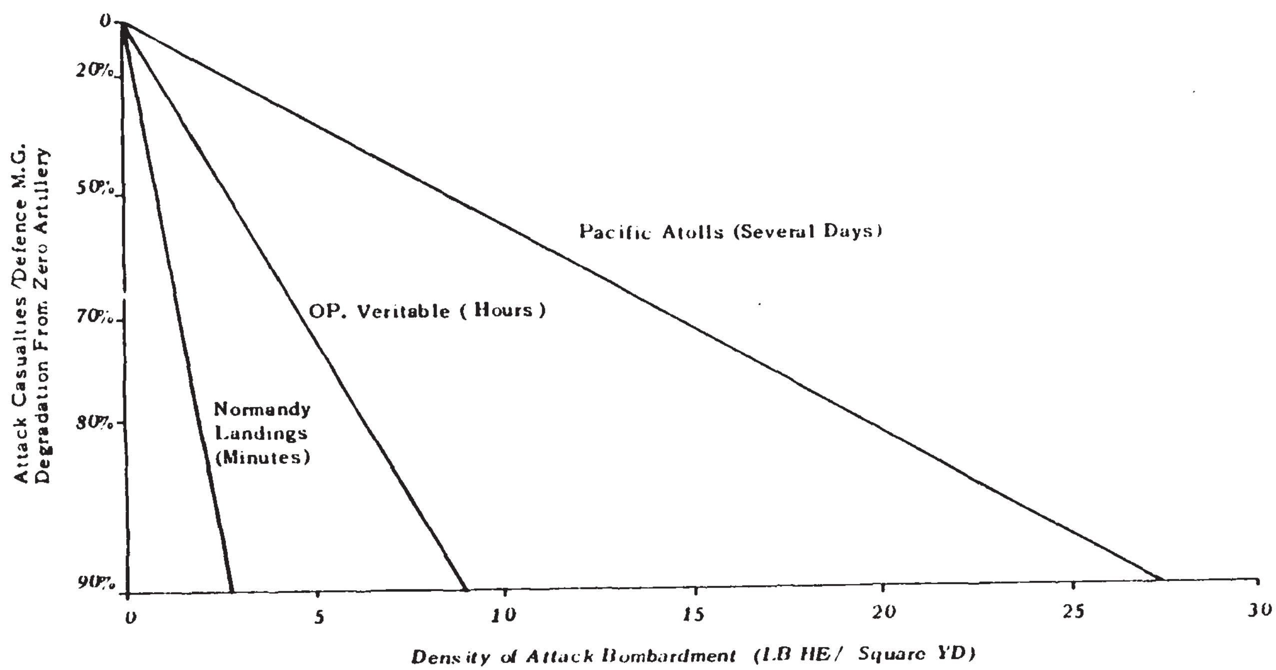


FIG 6. EFFECT OF DURATION OF BOMBARDMENT ON THE DEGRADATION IN INFANTRY FIREPOWER FOR A GIVEN DENSITY OF BOMBARDMENT

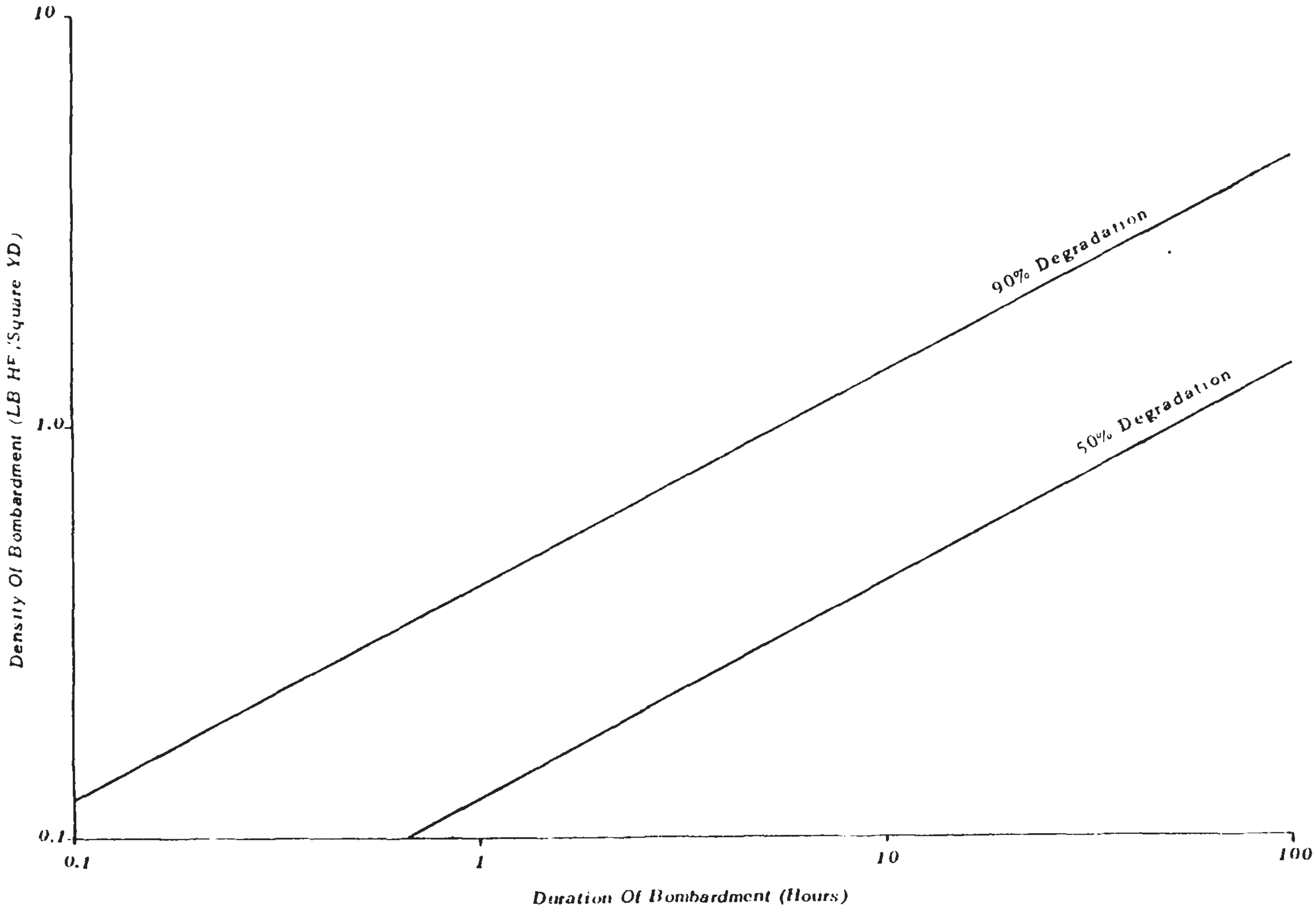


FIG 7. RELATIONSHIP BETWEEN DENSITY OF PREPARATORY ATTACK BOMBARDMENT AND ITS DURATION TO ACHIEVE A GIVEN LEVEL OF DEGRADATION IN INFANTRY FIREPOWER, FROM ZERO ARTILLERY DENSITY

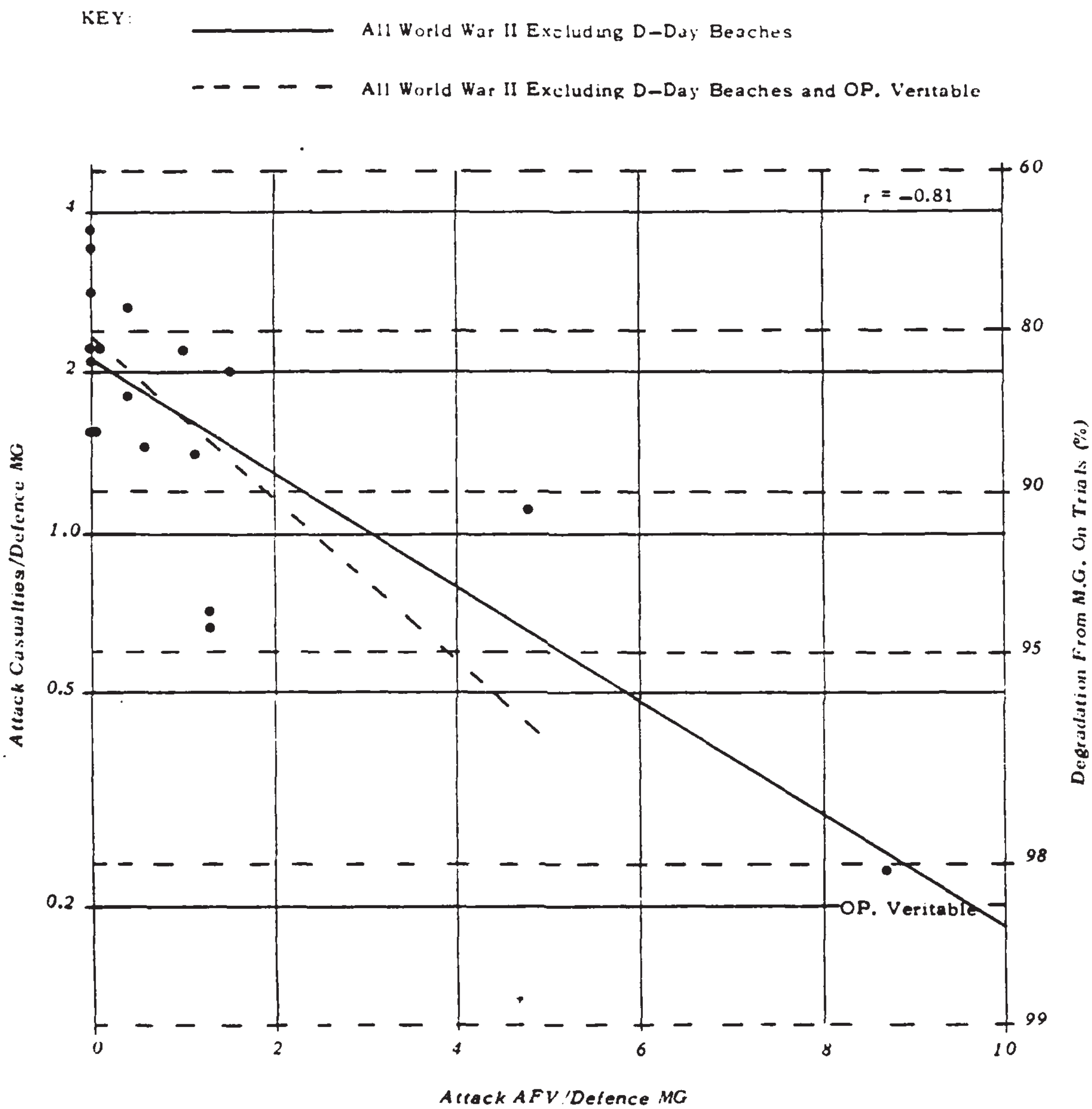


FIG 8. DEFENCE MG. EFFECTIVENESS AND ATTACK TANK DENSITY FOR WORLD WAR II BATTLES EXCLUDING D-DAY BEACHES

(At 1:1 Force Ratio Zero Artillery Bombardment)

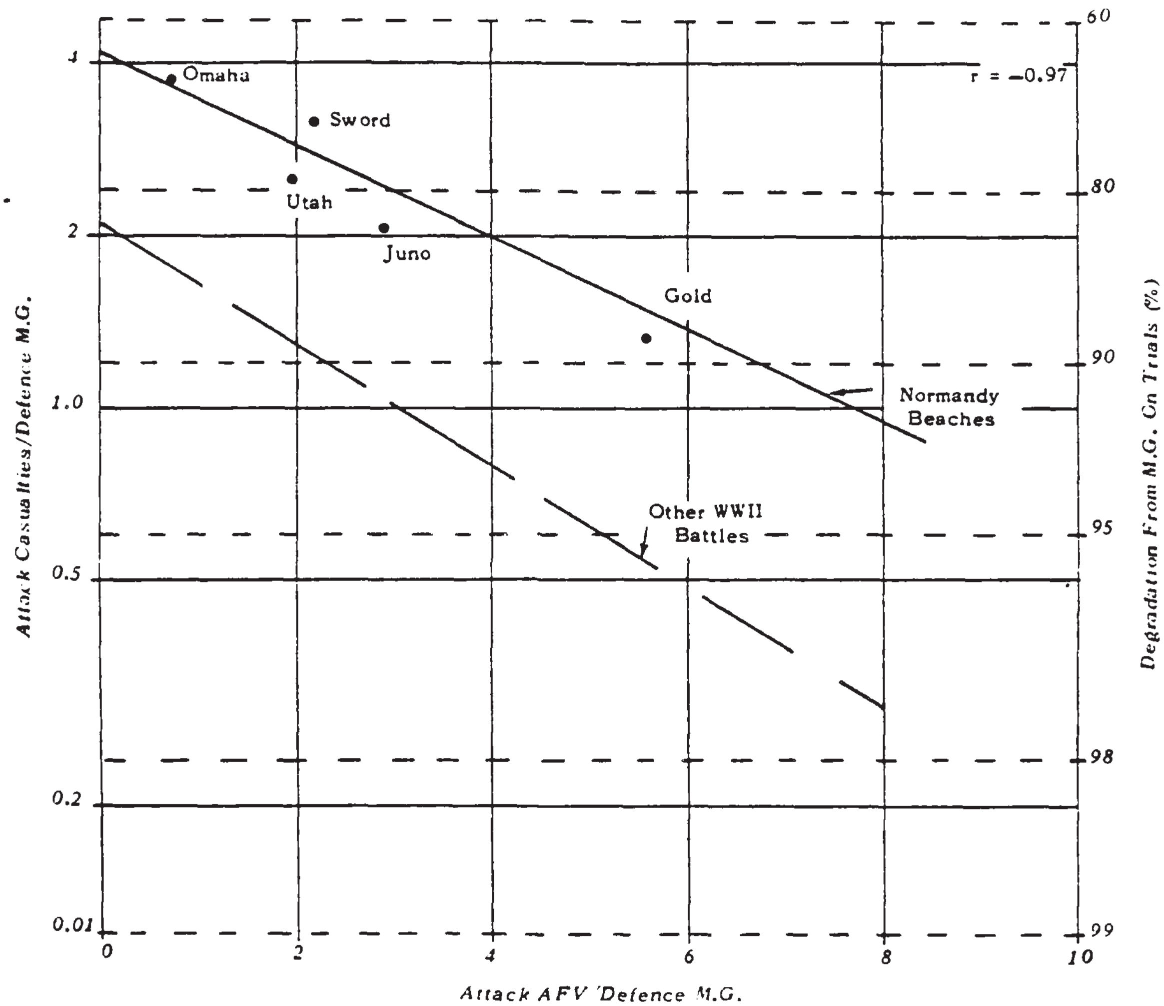


FIG 9. DEFENCE M.G. EFFECTIVENESS AND ATTACK TANK DENSITY FOR NORMANDY BEACHES, WWII

(At 1:1 Force Ratio, Zero Artillery Bombardment)

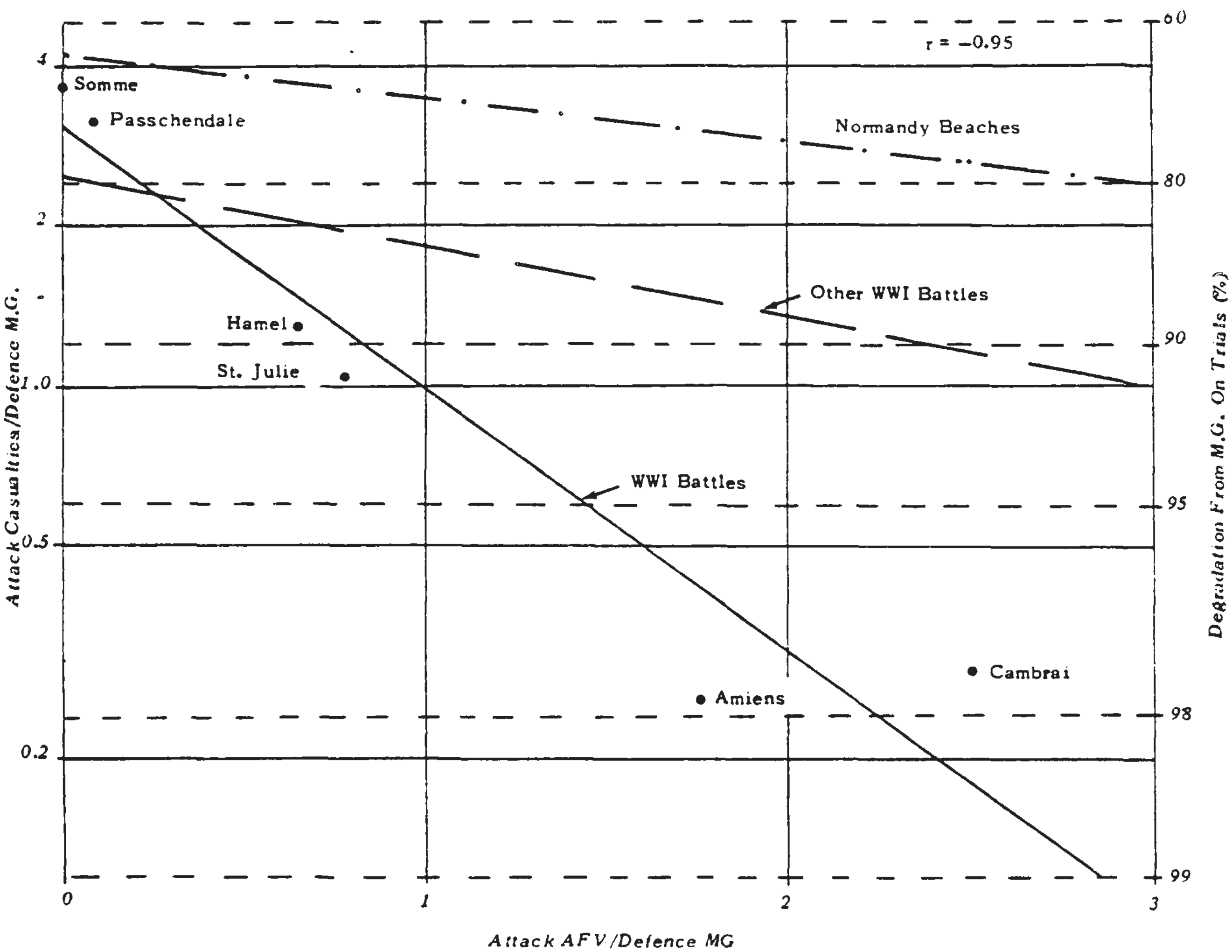


FIG 10. DEFENCE M.G. EFFECTIVENESS AND ATTACK TANK DENSITY FOR WORLD WAR I BATTLES

(At 1:1 Force Ratio Zero Artillery Bombardment)

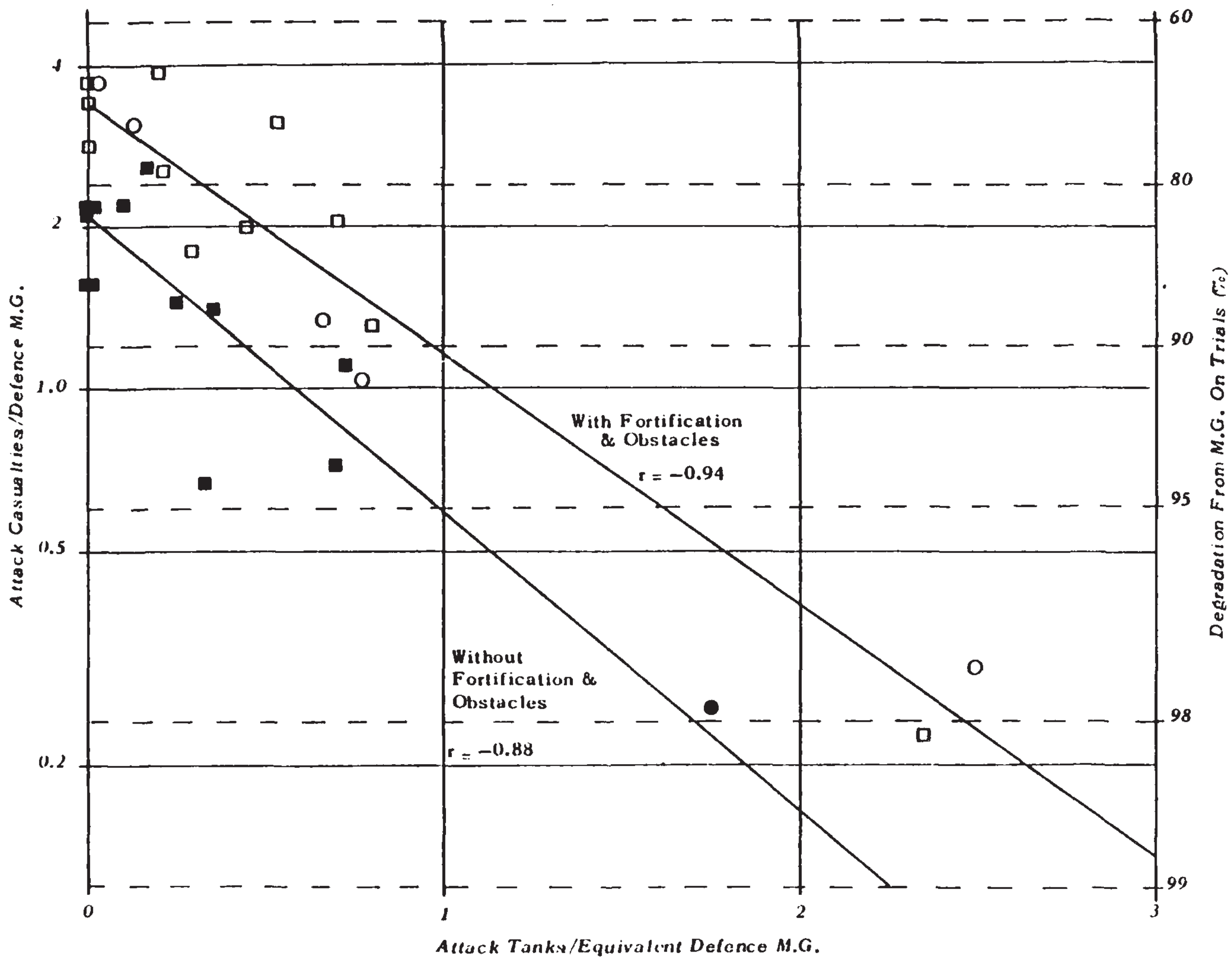


FIG 11. DEFENCE M.G. EFFECTIVENESS AND TANK DENSITY, TAKING ACCOUNT OF DEFENCE ANTI-TANK WEAPONS AS EQUIVALENT M.G.

(At 1:1Force Ratio, Zero Artillery Bombardment)

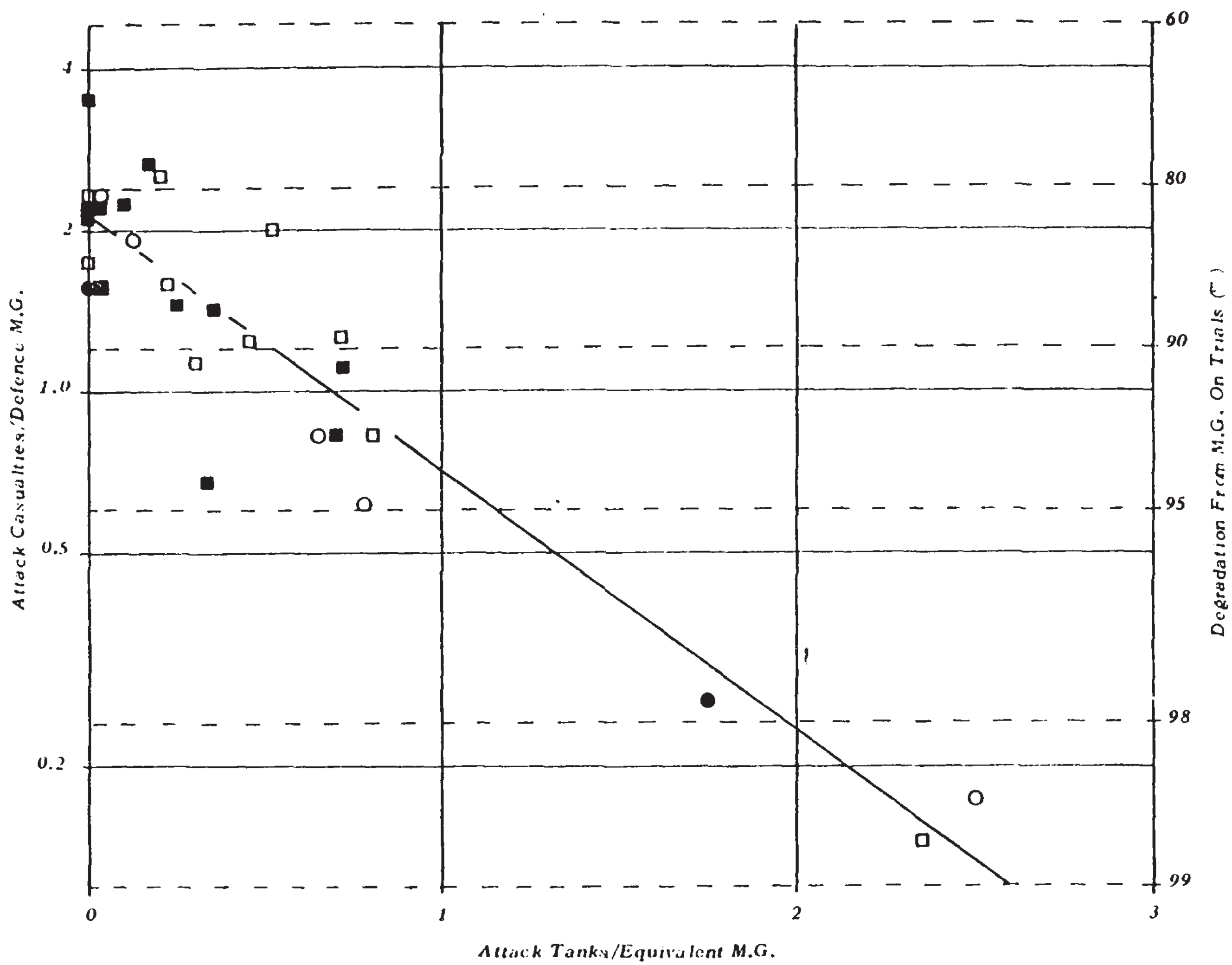


FIG 12. DEFENCE M.G. EFFECTIVENESS AND TANK DENSITY, CORRECTED TO ZERO FORTIFICATION

(At 1:1 Force Ratio, Zero Artillery Bombardment)

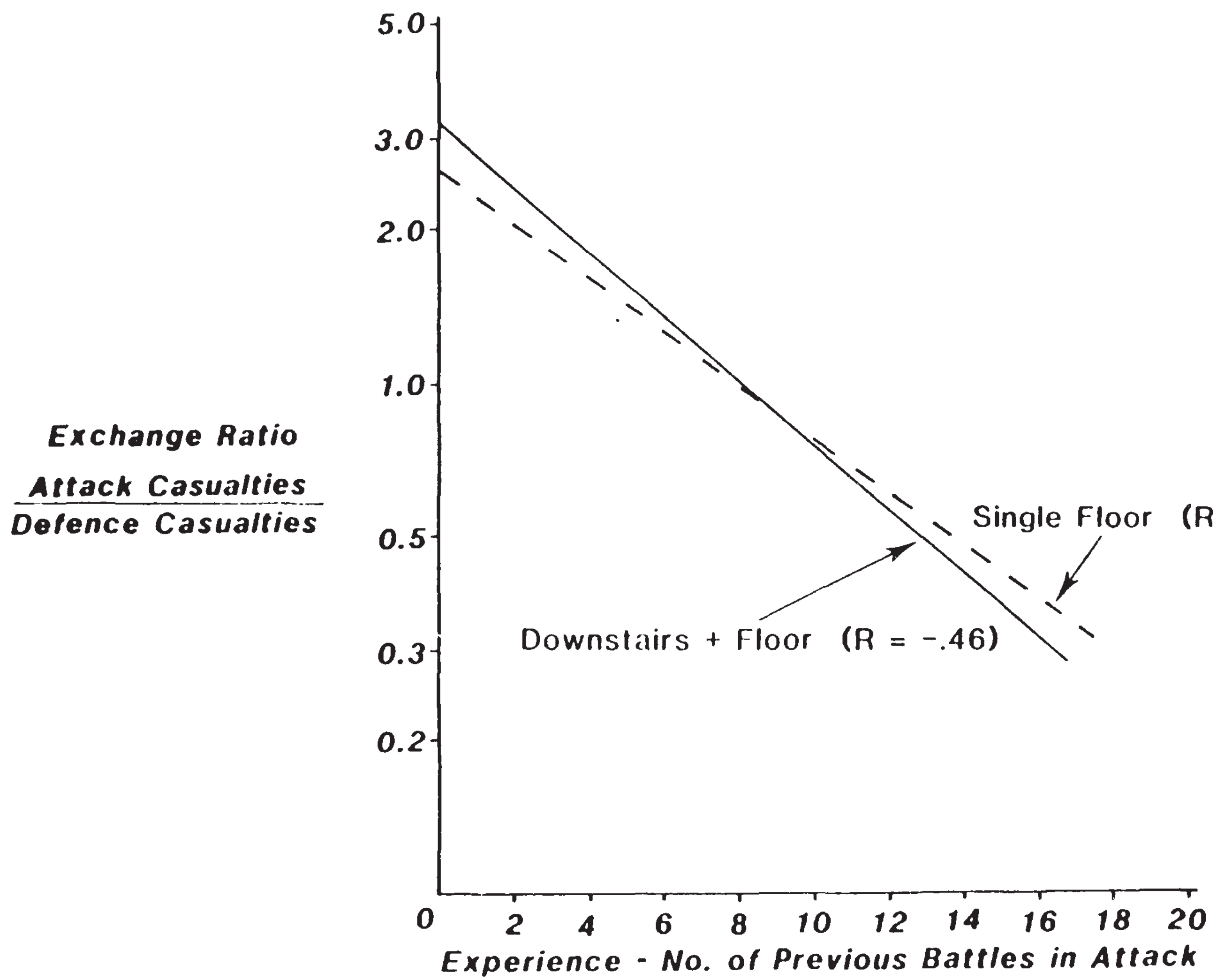


FIG 13. FIBUA – HOUSE CLEARANCE
EFFECT OF EXPERIENCE

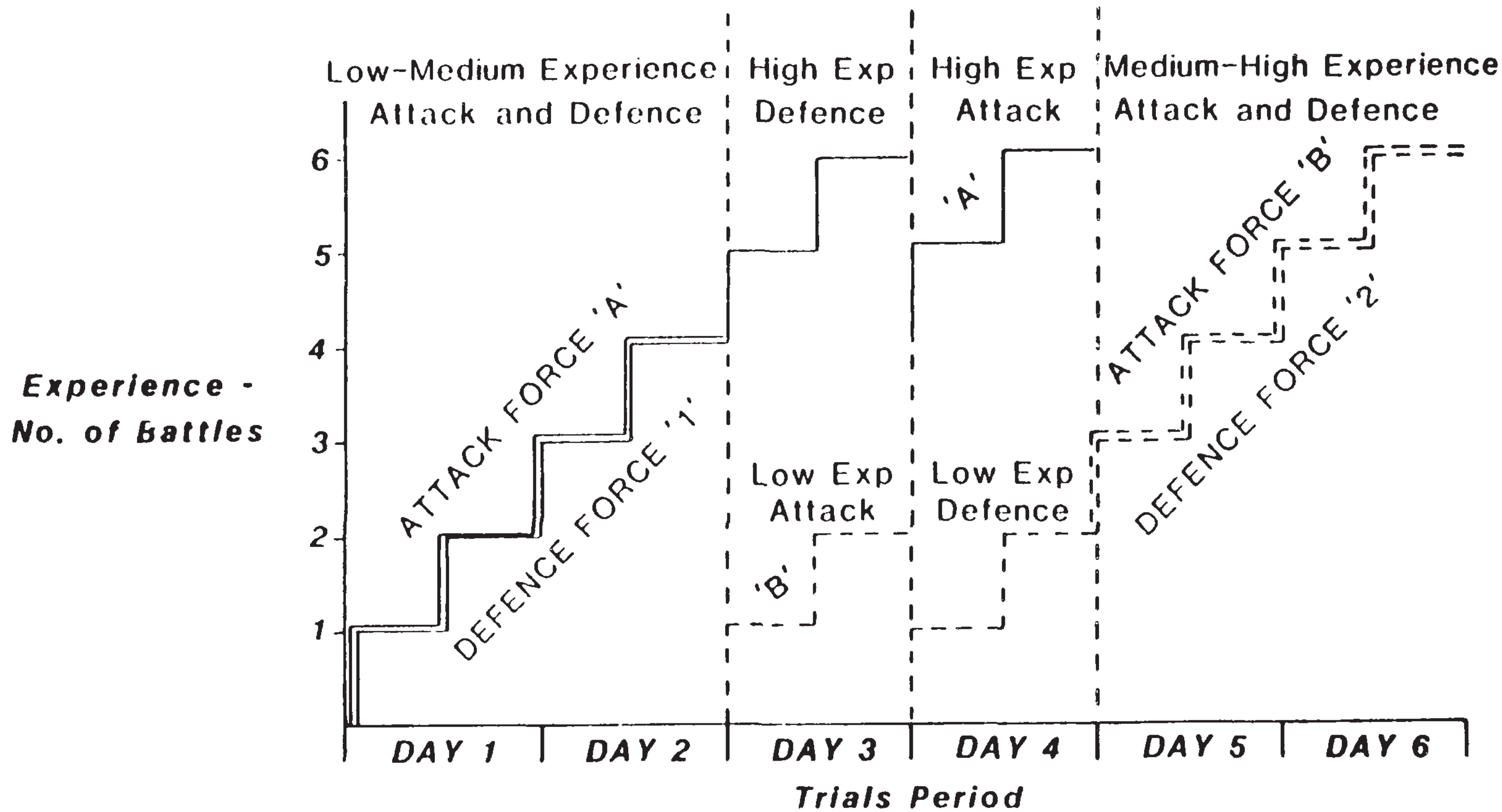


FIG 14. FIBUA TRIAL – BERLIN 1985
DESIGN

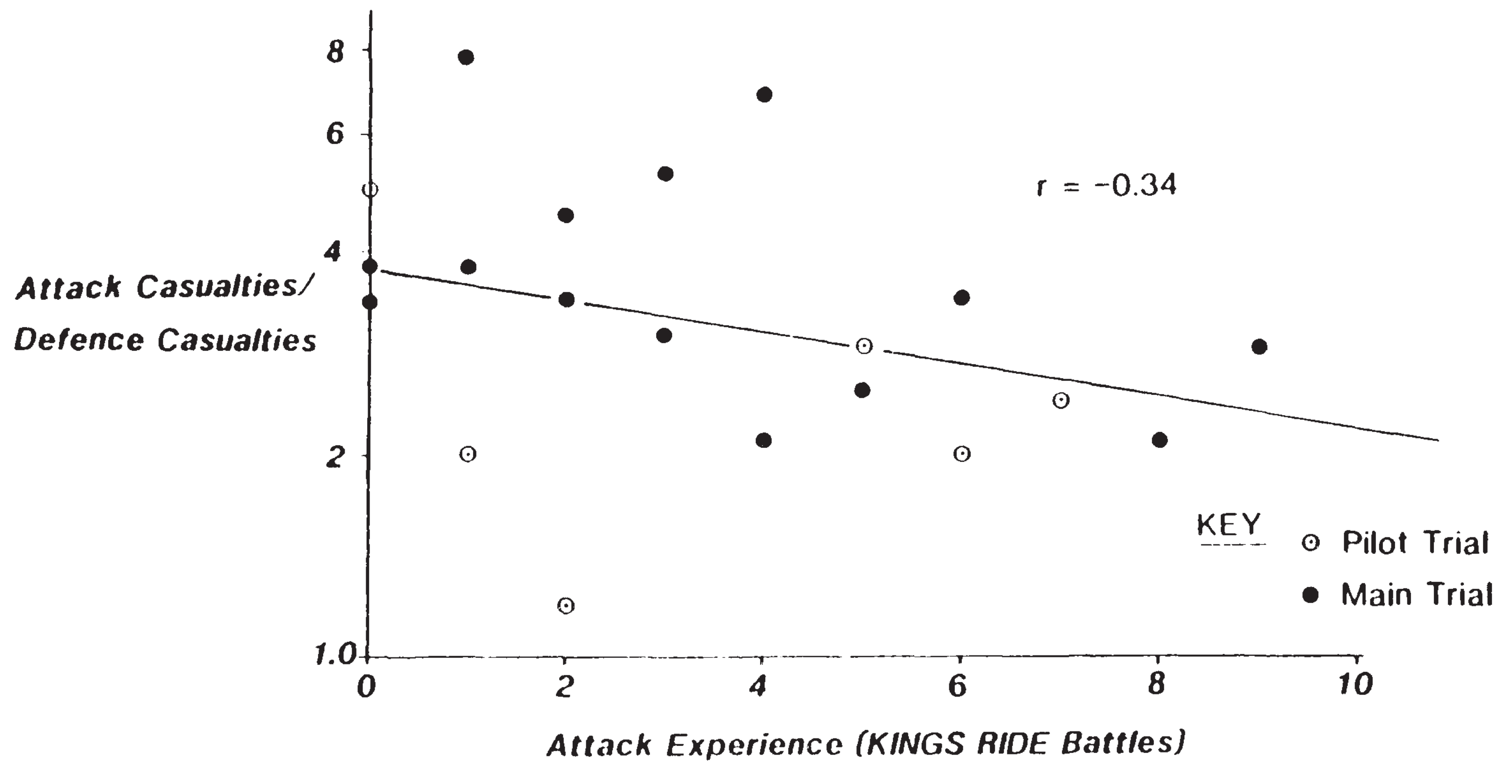


FIG 15. EFFECT OF ATTACK EXPERIENCE ON EXCHANGE RATIO AS A MEASURE OF DEFENCE EFFECTIVENESS

(3.5:1 FORCE RATIO)

SIMULATED COMBAT		LIVE COMBAT
100	KILLED	20
0	WOUNDED/POW	60
0	ESCAPE/WITHDRAW	20

FIG 16. DEFENCE CASUALTIES (%)

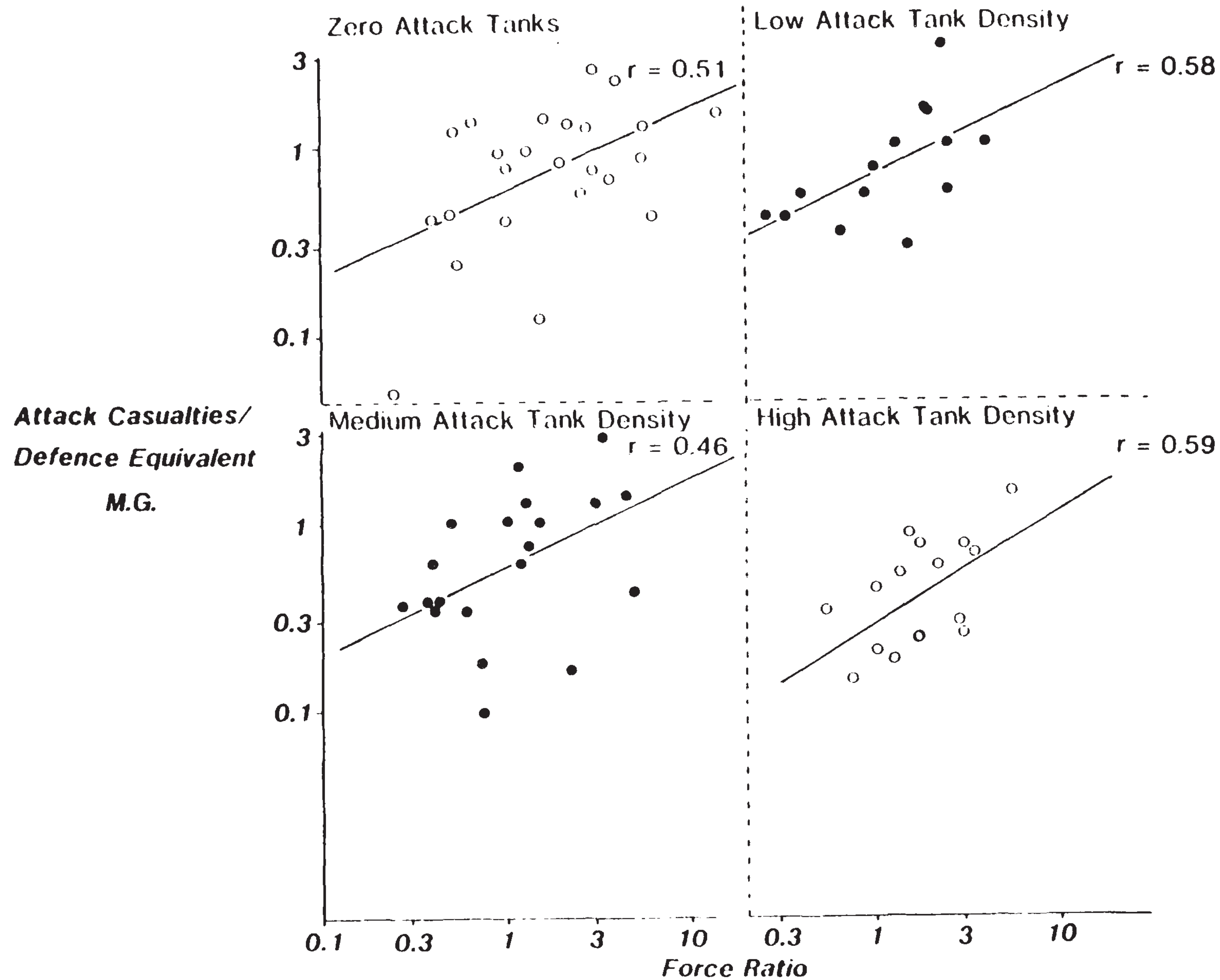


FIG 17. EFFECT OF FORCE RATIO ON ATTACK CASUALTIES/DEFENDER

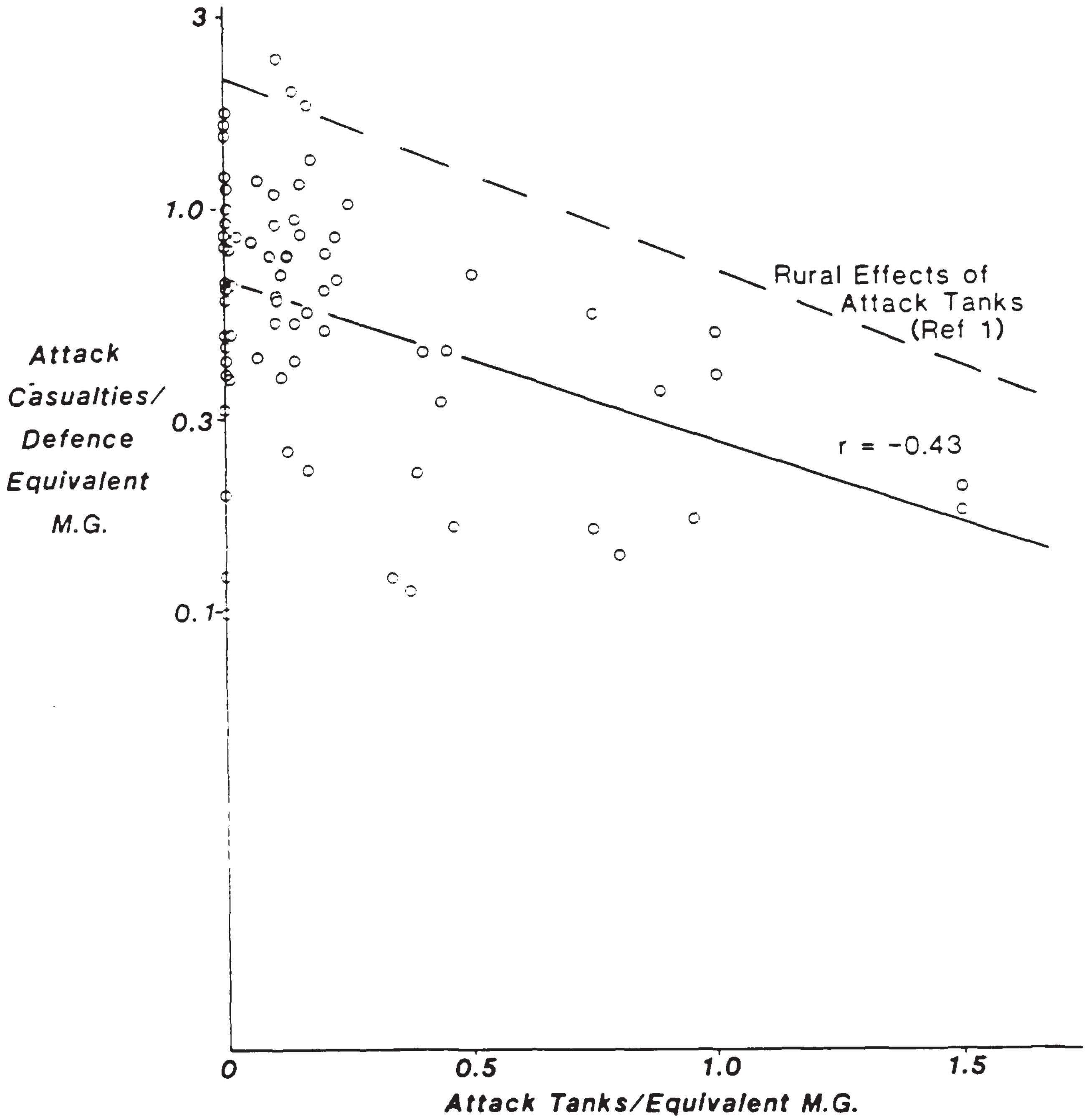


FIG 18. EFFECT OF ATTACK TANKS ON DEFENCE INFANTRY EFFECTIVENESS
(AT 1:1 FORCE RATIO)

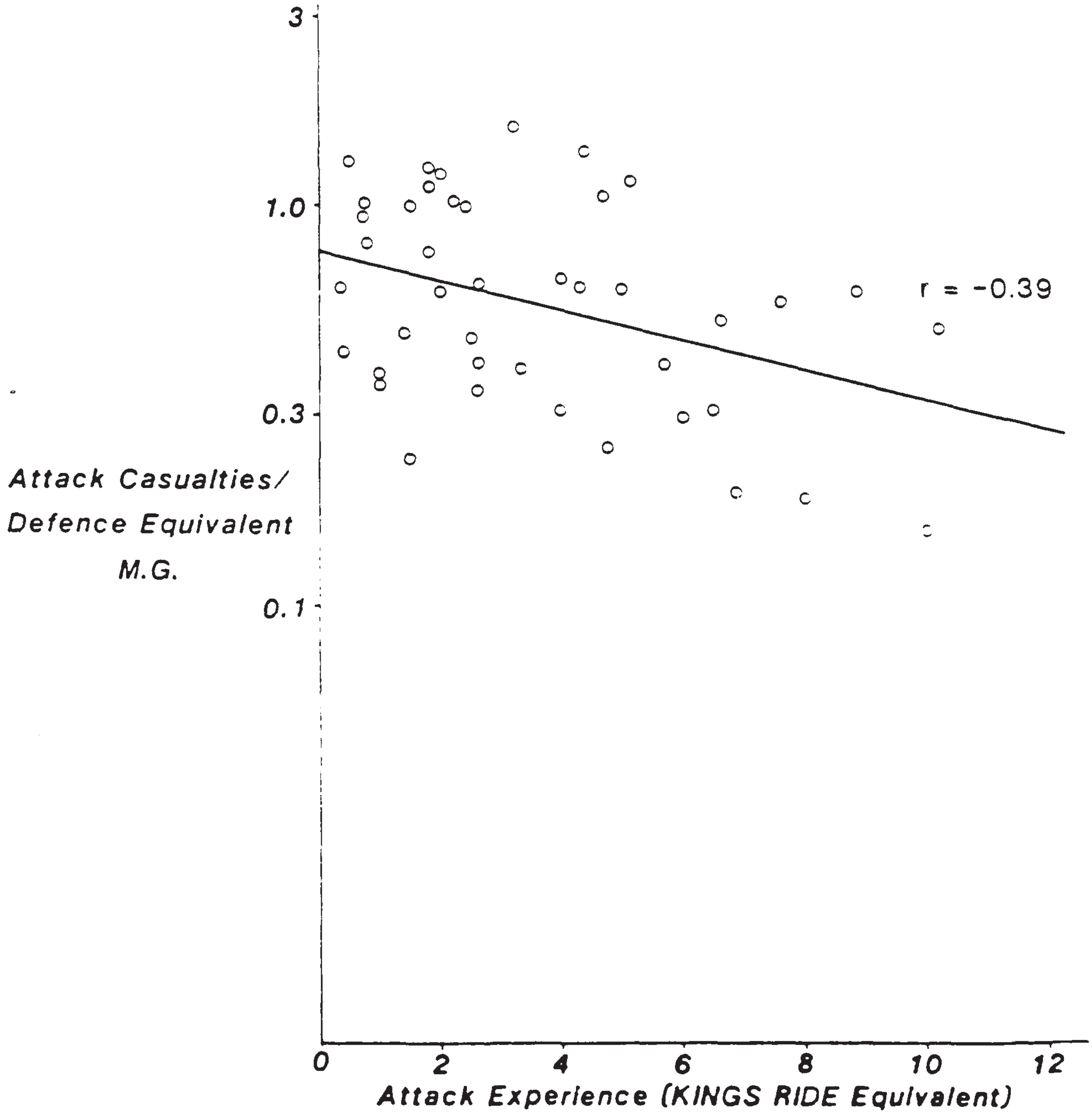


FIG 19. EFFECT OF ATTACK EXPERIENCE ON DEFENCE INFANTRY EFFECTIVENESS
(AT 1:1 FORCE RATIO, ZERO ATTACK TANKS)

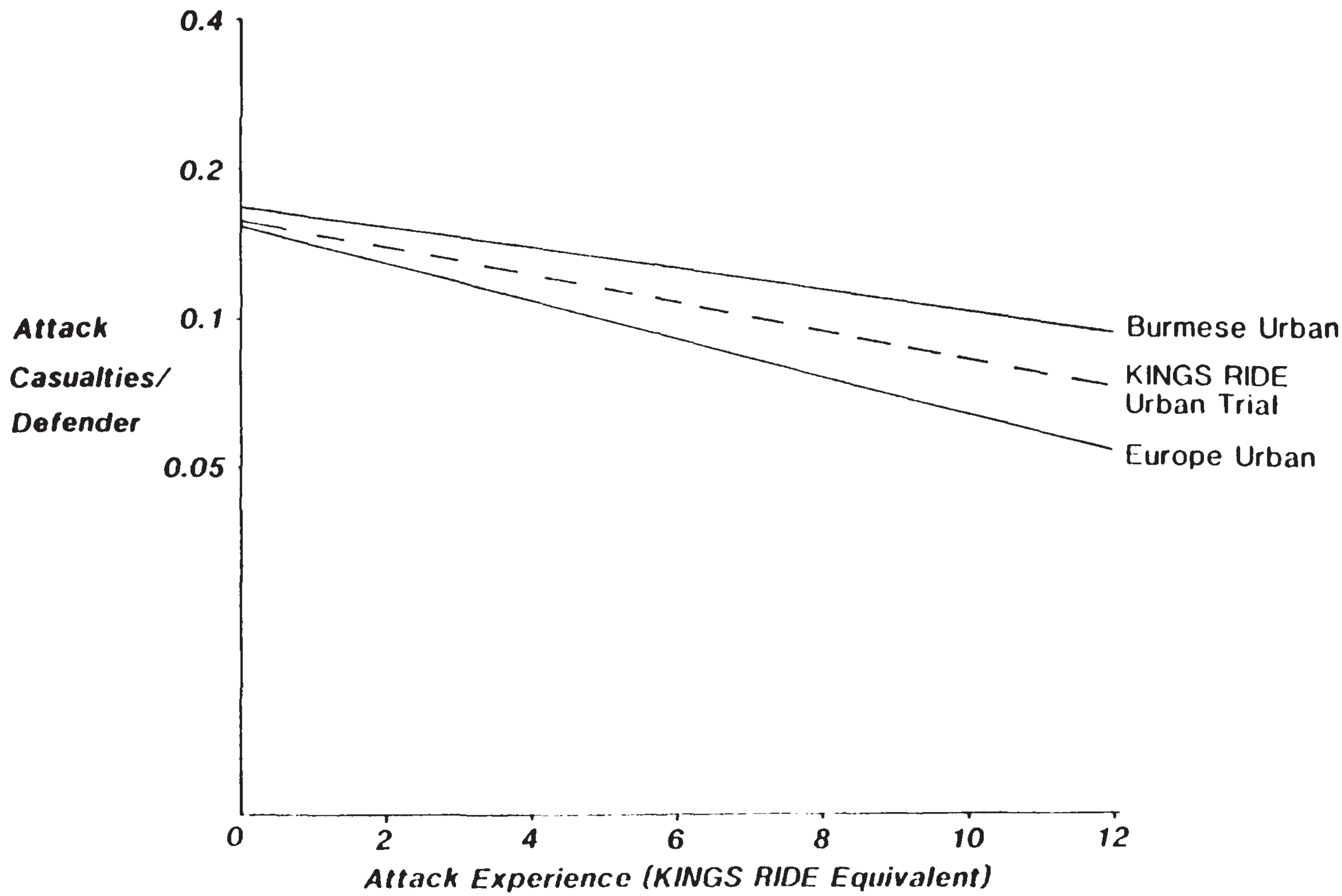


FIG 20. COMPARISON OF BURMESE URBAN WITH OTHER DATA SOURCES
(1:1 FORCE RATIO, ZERO ATTACK TANKS, 1 MG/SECTION)

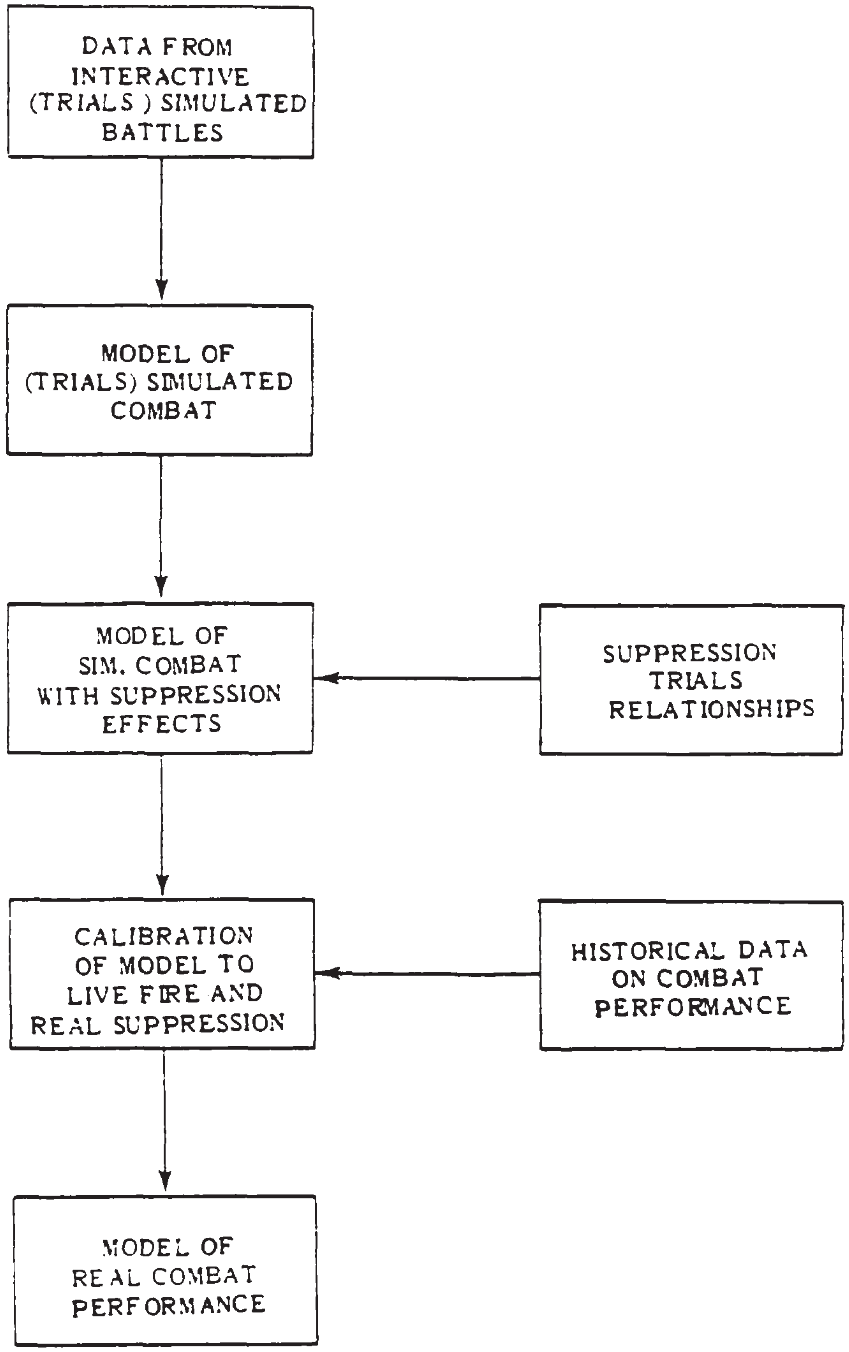


FIG 21. SCHEMATIC DIAGRAM OF COMBAT MODEL DEVELOPMENT (HELICCS) INCORPORATING HISTROICAL DATA

At Phase 1 a stochastic model was constructed which specifically represented:-

a. Individual weapons and men.

b. Attack movement in two dimensions (specified in scenario).

c. Intervisibility.

d. Weapon rates of fire with target availabilities search arc and range.

e. Lethality of each weapon firing - both in exercise (weapon simulators) and live fire conditions (weapons with live ammunition).

f. Overkill.

g. Defence open fire rules.

FIG 22. PHASE 1: DEVELOPMENT OF THE HIGH RESOLUTION MODEL HELICCS

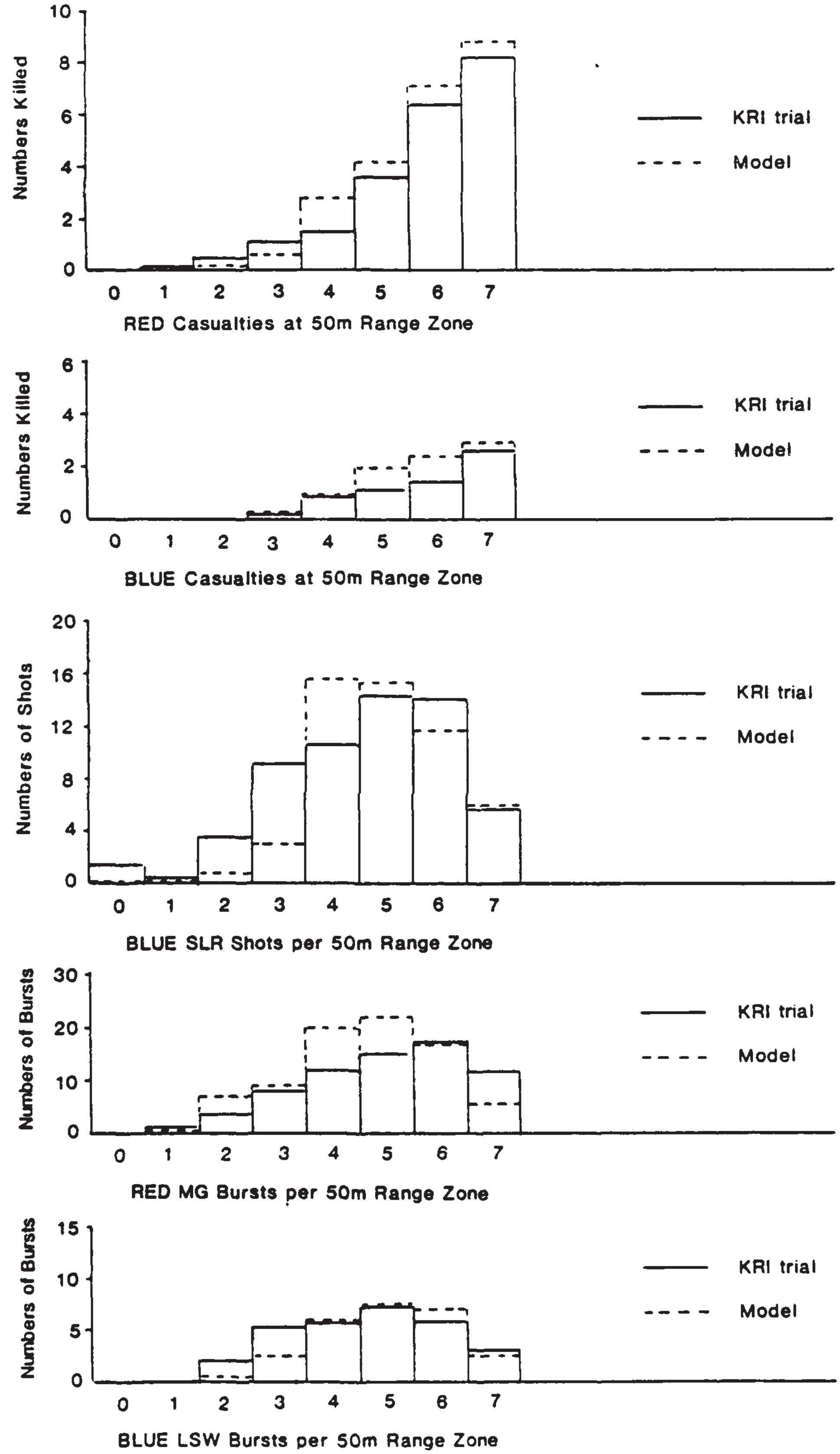


FIG 23. A COMPARISON OF MEAN MODEL AND TRIAL PARAMETERS – EX KINGS RIDE I

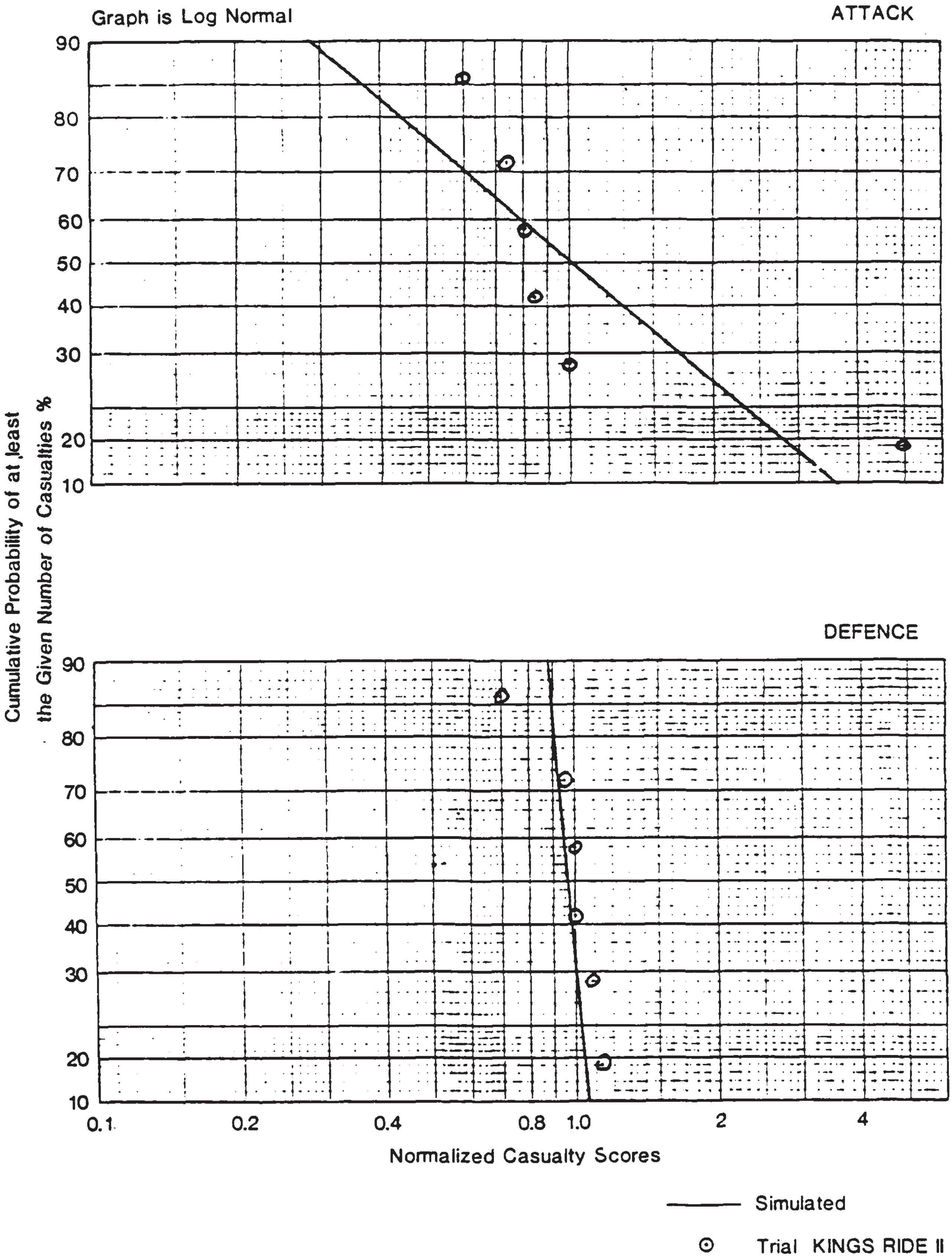


FIG 24. A COMPARISON OF MEAN MODEL AND TRIAL PARAMETERS - EX KINGS RIDE II

The Elaboration phase developed the Phase 1 model to include representation of:-

a. Direct fire suppression by small arms.

b. Direct fire suppression by AFV.

c. Degradation, as a result of suppression due to presence of live fire.

d. The effect of attack artillery in causing defence casualties and subsequent suppression.

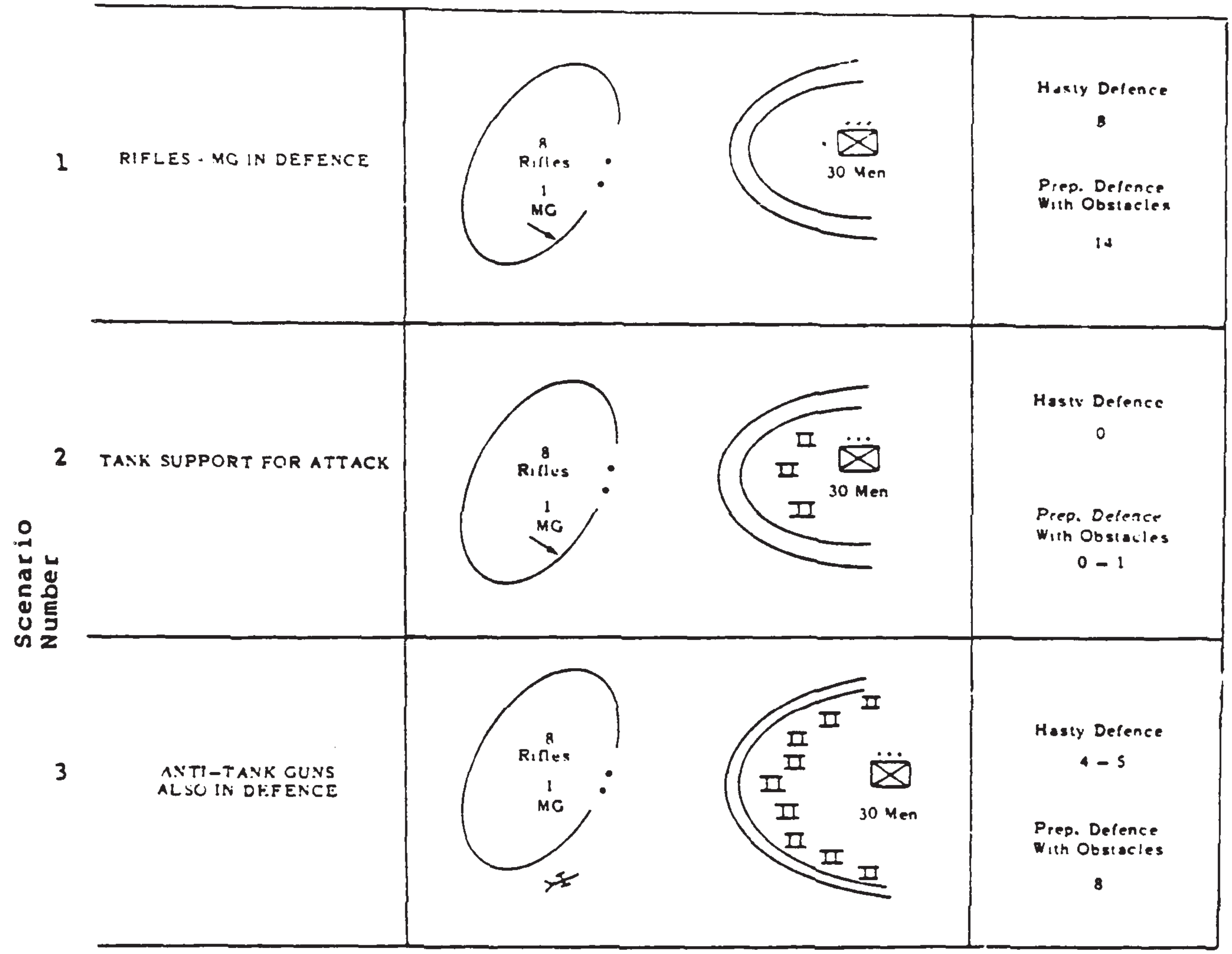
e. The effect of defence artillery in causing attack casualties.

f. Infantry anti-tank weapons.

g. The continuation of the battle to the overrun or close quarters battle phase, using data from Ex Kings Ride IIC.

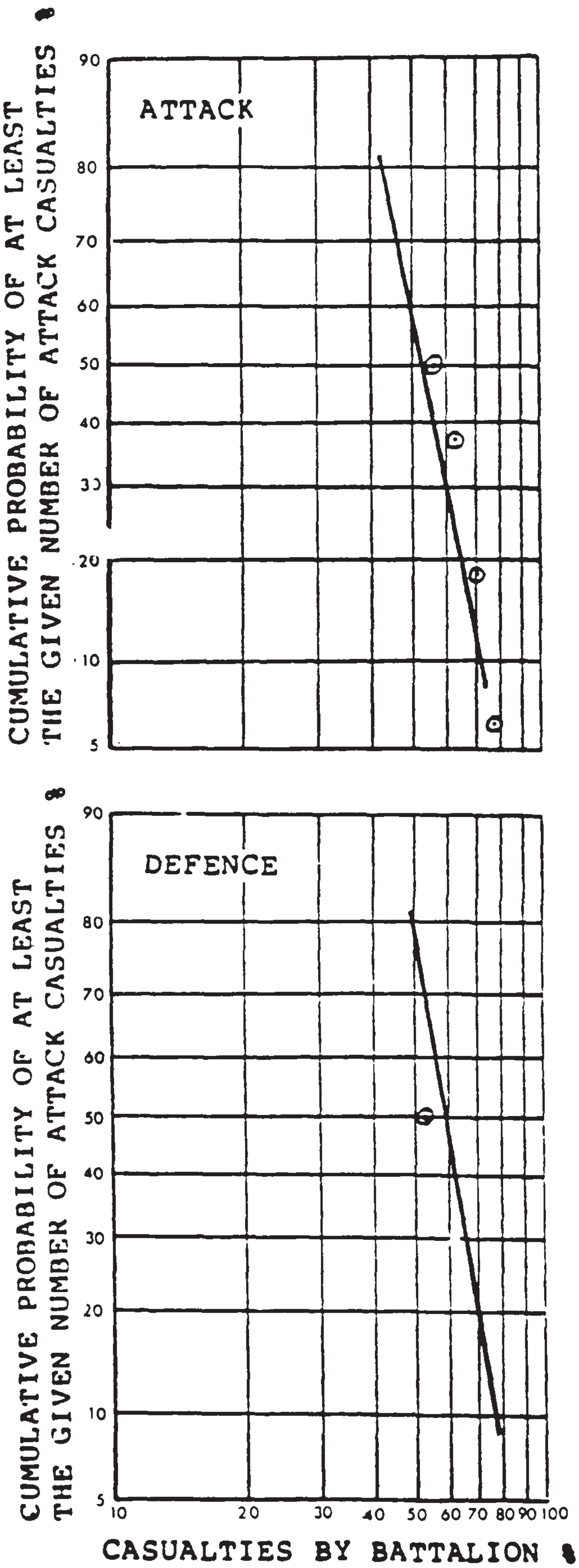
h. The probability of attack withdrawal, defence withdrawal or defence surrender with casualty level and other factors.

FIG 25. PHASE 2: ELABORATION OF THE HELICCS MODEL



Run/Study Description	Attack Casualties for Scenario 1	2	3
Final simulation set all calibration complete. Mean from 10 replications	8.2	0.8	6.1
Repeat of the above with 25 replications per Scenario. Mean	7.7	1.6	6.1
s.d.	2.6	1.8	2.4
DOAE study results for unprepared defence	8	0	4.5
DOAE study results for prepared defence (ie: with obstacles)	14	0-1	8

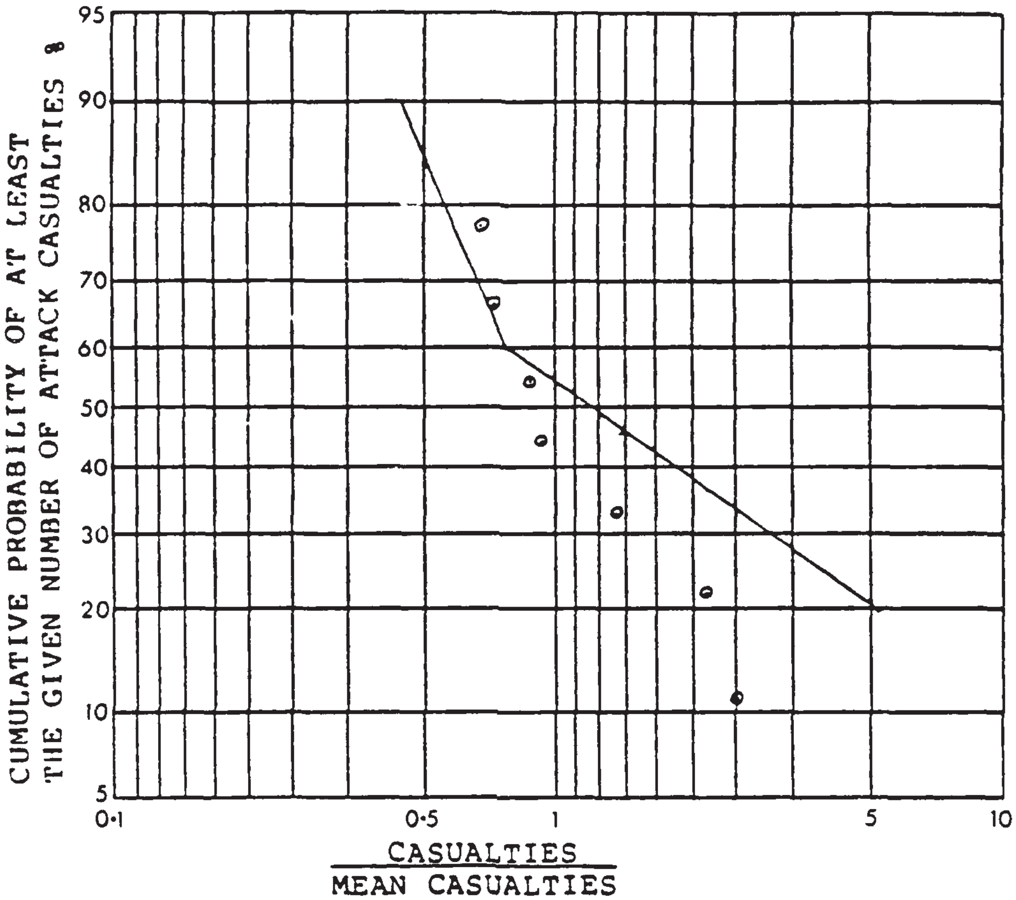
FIG 26. SUMMARY OF CALIBRATION OF SUPPRESSION RESULTS



Graph is Log Normal
Gradient (s.d) is a
measure of variability

——— MODEL RESULTS
⊙ HISTORICAL DATA

FIG 27. COMPARISON OF MODEL AND RECORDED CASUALTIES FOR THE FIRST DAY ON THE SOMME



Graph is Log Normal
Gradient (s.d) is a measure of variability

—— MODEL RESULTS
⊙ HISTORICAL DATA

FIG 28. COMPARISON OF THE MODEL AND RECORDED ATTACK CASUALTIES FOR THE D-DAY BEACH LANDINGS